

# **Demonstration Project: Protection and Enhancement of Delta In-Channel Islands**

**June 2006**

**CALFED Project # 2001-E200 and Amendment Contract # 01-N13-ERP Phase II**

## **FINAL MONITORING REPORT**



### **Prepared by the Delta In-channel Work Group**

**Cooperating Parties: Association of Bay Area Governments • CALFED • Delta Protection Commission • DFG • DWR • LSA Inc. • Hart Restoration Inc. • Kjeldsen Biological Consulting • KSN Engineers • LFR Levine-Fricke • MBK Engineers • DCC Engineering • San Francisco Estuary Project • State Lands Commission • US Fish and Wildlife Service**

## **Transmittal**

### **Subject: Final Monitoring Report, Demonstration Project for the Protection and Enhancement of Delta In-Channel Islands, Sacramento-San Joaquin Delta, California. CALFED Project # 2001-E20 and Amendment Contract # 01-N13-ERP Phase II**

Delta In-Channel Island Workgroup (DICIW) presents this Final Monitoring Report on the Demonstration Project for the Protection and Enhancement of Delta In-Channel Islands. This report documents results of four years of monitoring on the initial project and one year on the amendment (see also previous annual reports). The project has been recognized with an "Outstanding Comprehensive Conservation and Management Plan (CCMP) Implementation Award" at the State of the Estuary Conference 2003.

The project was undertaken to demonstrate the feasibility of "environmentally friendly" methods for the stabilization of in-channel islands and their adjoining levees. The baseline biological and physical data collection for the candidate in-channel islands was completed in 1997. The CALFED Demonstration Project allowed the design and installation of eleven types of biotechnical wave and erosion control structures (modified to fourteen with adaptive management including the amendment which allowed the construction in 2004-05 of a "woody debris pile" contract # 01-N13-ERP). The biotechnical wave and erosion control structures were installed in various combinations along three Delta in-channel islands. Construction at Webb Tract III was initiated in 2000 with final installation in October 2001, Little Tinsley Island was completed in November 2001, and Webb Tract I was completed in August 2002. The construction for the Amendment (Anchored Woody Debris Pile) on Webb III was initiated in 2004 and completed in 2005. The biotechnical wave and erosion control structures were sited to test different wave, tide and current exposure. The biological and hydrogeomorphic monitoring completed to date indicates that the biotechnical wave and erosion control structures were constructed and function as designed. Adaptive management has resulted in the abandonment of ineffective floating log booms and mulch pillows for tule plantings, dictated a retrofitting of the initial design for log wave breakers and a new design for the subsequent construction of buttressed log wave breakers, and modification of the tethered floating log planter. The report includes design schematics for each of the wave and erosion control structures and observations on longevity of the experimental structures.

We have observed and anticipate continued stabilization and/or reversal of shoreline erosion. We have found an increase in emergent vegetation, and ongoing protection from erosion conserving productive terrestrial and aquatic habitats that support important fish, wildlife, and plant communities. The project resulted in an increase the growth of tules which are the "ecosystem engineers" of the Delta. In addition there has been an increase in the presence and growth of special-status plant species behind the biotechnical wave and erosion control structures. Biotechnical designs are an alternative to "hard" revetment strategies (rock riprap) and may be a key component of the future for selected areas in the Delta.

We submit that this demonstration project is a positive model for future projects that deal with preserving and constructing new land/water interfaces specifically in the Delta, but world wide in practice. We anticipate that the project will provide options for future In-channel Island management and restoration efforts, levee protection, and tidal wetland protection in the Sacramento-San Joaquin Delta and elsewhere.

The attached insert (Erosion Protection of Delta In-Channel Islands) is provided as a general use summary for the project.

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CALFED Project # 2001-E200 and Amendment Contract # 01-N13-ERP Phase II

## CONTENTS

### ABSTRACT

### SUMMARY INSERT: Erosion Protection of Delta In-channel Islands

|            |                                  |           |
|------------|----------------------------------|-----------|
| <b>1.0</b> | <b>INTRODUCTION.....</b>         | <b>1</b>  |
| 1.1        | Project Background               |           |
| 1.2        | Conceptual Model                 |           |
| 1.3        | Objectives                       |           |
| 1.4        | Schedule                         |           |
| <b>2.0</b> | <b>BIOLOGICAL METHODS.....</b>   | <b>14</b> |
| 2.1        | Wildlife                         |           |
| 2.1.1      | Purpose                          |           |
| 2.1.2      | Survey Protocol and Methods      |           |
| 2.1.3      | Species of Concern               |           |
| 2.2        | Vegetation                       |           |
| 2.2.1      | Purpose                          |           |
| 2.2.2      | Survey Protocol and Methods      |           |
| 2.2.3      | Species of Concern               |           |
| 2.2.4      | Non-Native Species               |           |
| 2.3        | Photomonitoring Stations         |           |
| 2.3.1      | Methods                          |           |
| 2.4        | Fisheries                        |           |
| <b>3.0</b> | <b>HYDRODYNAMIC METHODS.....</b> | <b>19</b> |
| 3.1        | Purpose                          |           |
| 3.2        | Survey Protocol and Methods      |           |
| <b>4.0</b> | <b>BIOLOGICAL RESULTS.....</b>   | <b>21</b> |
| 4.1        | Webb Tract I                     |           |
| 4.1.1      | Wildlife                         |           |
| 4.1.2      | Vegetation                       |           |
| 4.2        | Webb Tract III                   |           |
| 4.2.1      | Wildlife                         |           |
| 4.2.2      | Vegetation                       |           |
| 4.3        | Little Tinsley Island            |           |
| 4.3.1      | Wildlife                         |           |
| 4.3.2      | Vegetation                       |           |
| <b>5.0</b> | <b>HYDRODYNAMIC RESULTS.....</b> | <b>34</b> |
| <b>6.0</b> | <b>DISCUSSION.....</b>           | <b>36</b> |
| 6.1        | Summary Of Findings              |           |
| 6.2        | Adaptive Management              |           |
| 6.4        | Future Considerations            |           |
| 6.5        | Observations And Lessons Learned |           |
| <b>7.0</b> | <b>REFERENCES.....</b>           | <b>50</b> |

## **PLATES**

|     |                       |
|-----|-----------------------|
| I   | Location              |
| II  | Project Locations     |
| III | Webb Tract I          |
| IV  | Webb Tract III        |
| IIV | Little Tinsley Island |

## **FIGURES**

1. Typical in-channel island on an incoming tide as illustrated by the buoys.
2. Summary of erosion factors that impinge on the developed biotechnical structures. Note the loss of in-channel habitat from 1952 to 1978.
3. Tule mass that has been eroded off and is floating in mid channel.
4. Boat wakes along the shore of an in-channel island.
5. Percent area occupied by Tules behind the monitoring units on Webb Tract III. The data is comparing spring 2002 monitoring to fall 2005 monitoring.
6. Mason's Lilaeopsis growing behind brush wall on Webb III.
7. Percent area occupied by Tules behind the monitoring units on Little Tinsley. The data is comparing spring 2002 monitoring to fall 2005 monitoring.

## **TABLES**

- I. Summary Of Conditions At In-Channel Island Study Sites.
- II. Summary Of Biotechnical Wave And Erosion Control Treatments.
- III. Objective 1: To Demonstrate That The Erosion Of The Delta's In-Channel Island Can Be Slowed, Stopped Or Reversed Using Appropriately Engineered Biotechnical Methods.
- IV. Objective 2: To demonstrate that biotechnical erosion control methods can be successfully installed with positive effects on important/priority fish and wildlife.
- V. Analysis of Change in Terrestrial Biota Utilization of Webb III Habitat.
- VI. Avifauna Utilization of Webb III.
- VII. Analysis of Vegetation Change Between Spring 2002 and Fall 2005 Webb Tract III.
- VIII. Analysis of Vegetation Change Between Fall 2002 and Fall 2005 Webb Tract III.
- IX. Analysis of Change in Terrestrial Biota Utilization of Little Tinsley.
- X. Comparison of avifauna utilization of Little Tinsley, excluding flyover.
- XI. Analysis of Vegetation Change Between Spring 2002 and Fall 2005 Little Tinsley.
- XII. Analysis of Vegetation Change Between Fall 2002 And Fall 2003 Little Tinsley.
- XIII. Summary of Effectiveness and Costs of Biotechnical Structures
- XIV. Summary of Biotechnical Devices at Monitoring Units and Vegetation Cover.
- XV. Summary of Biotechnical Devices at Monitoring Units and Tule Growth.
- XVI. Summary of Adaptive Management.

### **Appendix A Photomonitoring 2002 to 2005**

### **Appendix B Vegetation Survey Data Sheets 2002-2005**

### **Appendix C Design Schematics and Photographs of Biotechnical Wave and Erosion Control Structures**

### **Appendix D Proposal for Modular Constructed Woody Biotechnical Structures**

# Demonstration Project: Protection and Enhancement of Delta In-Channel Islands

April 2006

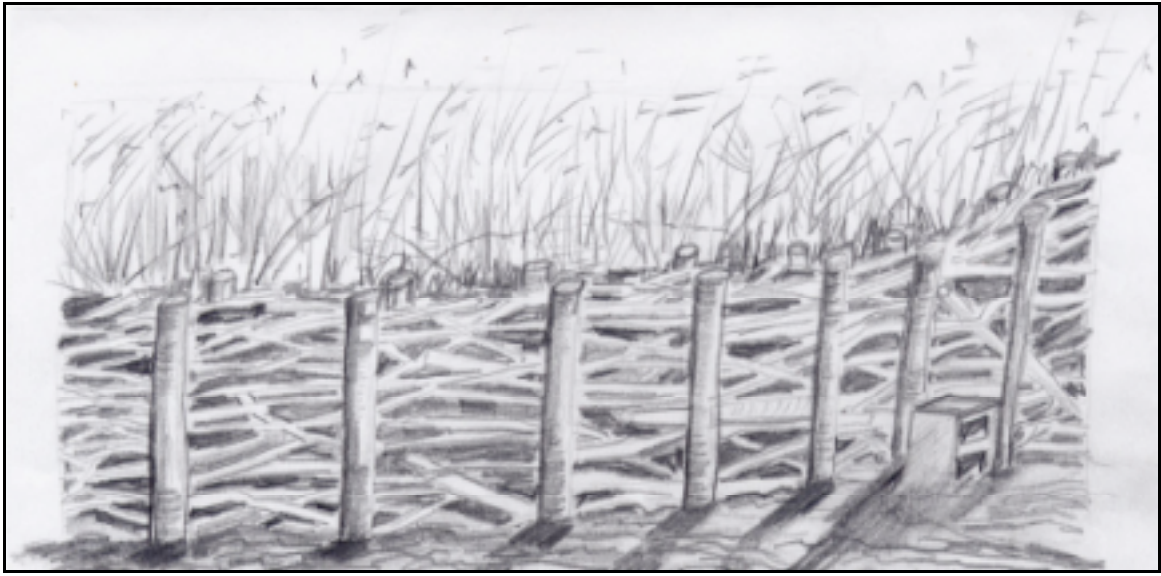
CALFED Project # 2001-E200 & Amendment Contract # 01-N13-ERP Phase II

## FINAL MONITORING REPORT

### ABSTRACT

*Historical and current land and water management practices and boating in California's Sacramento-San Joaquin River Delta have resulted in accelerated rates of natural resource losses especially for in-channel islands. To explore options for arresting the disappearance of in-channel islands, the Delta In-Channel Island Workgroup (DICIW) initiated a Demonstration Project to test eleven biotechnical wave and erosion control structures (modified to 14 with adaptive management) for preserving habitat and stabilizing the shoreline of Delta in-channel islands. The biotechnical erosion control structures were constructed primarily of organic materials (wood, brush and root wads). The biotechnical wave and erosion control structures were installed in various combinations along three Delta in-channel islands. The dominant inter-tidal vegetation on these islands is bulrush, locally called tules, (Scirpus californicus and S. acutus). Natural erosion control is achieved by tules which grow in the intertidal zone and function as "ecosystem engineers." The "old growth tules" persisting on in-channel islands are remnants of the vast Delta ecosystem which they supported. The tule culm is fast growing, flexible under wave impact, and the rhizomes are long-lived and tenacious at resisting erosion. Monitoring for the project is based on the Monitoring Plan submitted by DICIW and updated by CALFED (2002). The project has two objectives: 1) to demonstrate that the erosion of the Delta's in-channel islands can be slowed, stopped or reversed using appropriately engineered biotechnical methods and 2) to demonstrate that biotechnical erosion control methods can be successfully installed with positive effects on important/priority fish and wildlife. Seven hypotheses were tested and monitored for four years on three in-channel islands with different biological and physical characteristics. Hydrodynamic monitoring found that the designed structures reduced wave height by 35%-64% and wave energy by 57%-87%. The constructed biotechnical wave and erosion control devices stopped the loss of tules and the optimum configuration supported a 66% increase in tule cover. Undesirable non-naïve invasive plants did not establish within the monitoring units. The structures protected two special-status plants and provided conditions favorable for population increases. Large anchored rootwads were stable and effective in protecting in-channel islands from riverine tidal and flood current flow. High energy wave exposed tule shoals, as found at Webb Tract I, can be protected from erosion but only with aggressive and relatively expensive biotechnical structures. Brush walls with their porosity and flexibility effectively reduced wind and boat generated waves. Maintenance was shown to be necessary for extended function of the organic structures. With the State's renewed focus on protecting and improving habitat conditions in the Delta especially tidal wetlands, the lessons learned from this demonstration project should have broad application for ongoing and future restoration efforts.*

# Demonstration Project: Protection and Enhancement of Delta In-Channel Islands



## 1.0 Introduction

This report documents the final year of monitoring of the Demonstration Project for the Protection and Enhancement of Delta In-Channel Islands CALFED Project #2001-E200 (“the Project”). The report consists of two parts an insert Summary prepared for a general audience and a technical report that we trust meets the needs of CALFED. Please also refer to the previous three annual reports for yearly analysis of the project.

The anthropomorphic changes of Sacramento-San Joaquin Delta are linked directly to the California Gold Rush, statehood and development of present day water use in California. Human health as an agenda of the new State resulted in incentives that led to the development of levees around swamp and overflow lands for malaria control, transportation, agriculture and flood control. The Delta in its present state is a managed ecosystem with concurrent loss or reduction of natural functions. The project identified the need for methods which offer potential for natural applications that will retain and restore some of the functions of the system as well as to mitigate the effects of erosion.

The biotechnical erosion control structures were constructed primarily of organic materials (wood, brush and root wads). The dominant inter-tidal shoreline vegetation on these islands is bulrush, locally called tules (*Scirpus californicus* and *S. acutus*). Natural shoreline erosion control is achieved by tules which maintain or increase elevations in the intertidal zone through sediment stabilization and accretion and thus function as “ecosystem

engineers.” The tule culm is fast growing and flexible under wave impact and the rhizomes are tenacious at resisting erosion. The “Old Growth Tules” persisting on in-channel islands with their extensive long-lived rhizomes (these rhizomes rival some of the oldest living organisms of California) on in-channel islands are remnants of the vast Delta ecosystem.

Monitoring for the project is based on the Monitoring Plan submitted by the Delta In-Channel Island Workgroup (DICIW) and updated by CALFED (2002). The project has two objectives: 1) to demonstrate that the erosion of the Delta’s in-channel islands can be slowed, stopped or reversed using appropriately engineered biotechnical methods and 2) to demonstrate that biotechnical erosion control methods can be successfully installed with positive effects on important/priority fish and wildlife. Seven hypotheses were tested and monitored to evaluate the project objectives.

This report contains an analysis of the fourth year, post-construction measurements compared when possible to baseline measurements (Kjeldsen et. al. 1997) to quantify the objectives of the Monitoring Plan prepared by the Delta In-Channel Island Workgroup (DICIW), March 2002). The Monitoring Plan presents DICIW’s Project objectives, testable hypotheses, monitoring parameters, and data evaluation techniques developed to assess the progress of the Project. Further clarifications of monitoring protocols developed throughout monitoring period are presented in this report.

The report presents results of biological analysis, project schematics, photomonitoring, and summary of observations and lessons learned. The first two years of monitoring were conducted by Levine Fricke (LFR), EDAW Inc., and Kjeldsen Biological Consulting. The third and fourth year of monitoring was conducted by Kjeldsen Biological Consulting and peer reviewed by Richard Nichols of LSA Associates.

Swanson Hydrology and Geomorphology conducted the hydrodynamic monitoring presented in a report dated May 13, 2003 Monitoring of Bioengineered Bank Protection along Delta Islands.

Project construction and adaptive design was initiated by Hart Restoration Inc. and Ron Galindo Construction. These contractors have also been responsible for ongoing project maintenance and replacement. An as-built engineered survey of the project was completed in 2002 by Kjeldsen, Sinnock and Neudeck Inc. (KSN) for Webb Tract I and III. The lead contractor for the consulting and contracting team was Gilbert Cosio of MBK Engineers. General project oversight and guidance was provided by Marcia Brockbank, San Francisco Estuary Project and Margit Arambru, Delta Protection Commission DCICW. Kent Nelson, California Department of Water Resources, was the overall Project Coordinator.

## **1.1 Project Background**

Relict Sacramento-San Joaquin delta in-channel islands are small and scattered remnants of vast expanses of tidal wetlands which covered this area in pre-settlement times. The relict islands in the channels of the delta are not well mapped, their shoreline stability is not well known, their habitat values are not defined, and their relationship to the delta’s aquatic system is undemonstrated. For the citizens of the state, the delta is a significant resource that has a complex and sensitive physical, biological, and political environment. "The Sacramento-San Joaquin delta is part of the most modified and intensely managed estuary in north America" (closer and Nichols 1985).

On February 13, 1996, representatives of citizen groups, consulting companies and state and

federal resource agencies met to discuss the needs for developing a cooperative agreement and strategy for managing the Delta in-channel islands. The initial organization of the group was provided by the San Francisco Estuary Project and the Delta Protection Commission. The stakeholders consensus demonstrated that these in-channel islands are valuable functioning relicts of a complex and highly modified system. The stakeholder group also recognized that there was a need to develop means to maintain the habitat values associated with the in-channel islands of the Legal Delta of the Sacramento and San Joaquin Rivers. It is agreed that the function of in-channel islands must be understood for the development and implementation of future management decisions and that protection measures must be developed to preserve these eroding remnants of the Delta.



**Figure. 1.** Typical in-channel island on an incoming tide as illustrated by the buoys.

Delta in-channel islands (DICIs) are remnants of tule marshes left after dredging or reclamation by levee construction, now appearing as “islands” in the channels of the Sacramento-San Joaquin River Delta. DICIs are a vanishing resource due to sediment depletion, high channel fluvial velocities, greater tidal prisms, and increased wave erosion from wind fetch and boat wakes. The purpose of the Project is to develop and demonstrate the effectiveness of using biotechnical wave and erosion control methods to protect and retain these remnants of the original Delta. The design of the biotechnical wave and erosion control structures is intended to validate methods for stabilizing and enhancing three eroding DICIs that help protect levees from erosive forces and support populations of fish, wildlife, and endemic plants.

For this demonstration project the following biotechnical wave and erosion control structures were designed, built and tested on three different DICIs in the Sacramento-San Joaquin Delta:

- Brush Walls, Webb Tract III and Little Tinsley Island;
- Log Wave Breakers design 1 and 2, Little Tinsley Island;
- Buttressed Log Wave Breakers design 3, Webb Tract I;
- Small Log Wave Breaker, Little Tinsley Island;
- Rootwad Wave Breaker (Apple Rootwads placed within posts), Webb Tract III and Little Tinsley Island;
- Large Anchored Rootwads (large Eucalyptus root mass), Webb Tract III and Little Tinsley Island;
- Floating Log Boom, Webb Tract III;
- Mulch Pillows (fiber mats pinned to the substrate), Webb Tract III;
- Floating Log Planter with Mulch Pillows (modified for Ballast Buckets), Webb Tract I;
- Peaked Stone Dikes or Rock Groins; and
- Anchored Woody Debris Pile (as per amendment).

The selection of in-channel islands for study was the result of work by the candidate islands Subcommittee of the delta in-channel islands workgroup. The Subcommittee, chaired by Mr. Frank Gray, DFG, met regularly and conducted two field trips as part of the selection process. The goals of the Subcommittee were:

- 1) Protection and stabilization of in-channel islands with methods that will provide maximum habitat benefits,
- 2) Demonstrate that such project(s) are possible (establish a project in 1997),
- 3) Demonstrate different bank protection methods, and
- 4) Demonstrate an improvement in fish, wildlife, and aquatic habitat resources via pre- and post-project inventories.

The Workgroup identified as Selection Criteria the following:

- A). The project site must be an in-channel island,
- B). The project site must be consistent with mapped areas where flood control capacity reduction will not be an issue, and
- C). The site must avoid existing infrastructure.

The DICIW Workgroup identified the following Evaluation Criteria for consideration in the selection process:

- a). Site consistency with CALFED objectives,
- b). The site must present opportunities for demonstrating different biotechnical wave and erosion control structures,
- c). The site must have the potential for minimal adverse impacts to listed species,
- d). The site must maximize benefits to habitat,
- e). Average costs must not exceed \$100 to \$200 per lineal foot, and
- f). Land owner cooperation.

At the May 1, 1997, meeting of the Delta In-channel Workgroup, the Subcommittee submitted recommendations for the demonstration project. At the May 15, 1997, meeting, the Delta In-channel directed that the following objectives be addressed by the project design:

- a). Arrest / reverse erosion,
- b). Confirm / use what techniques work best,
- c). No imported fill (a "little" is acceptable), and
- d). Maximum restoration and habitat creation.

In march of 1997, the Delta Protection Commission, through an interagency agreement with the trustees of the California state university, entered into a work agreement to conduct baseline studies (Sacramento-San Joaquin Delta in-channel islands protection and management analysis) on Delta selected in-channel island project sites. The funding provided by the Delta Protection Commission allowed for the baseline study (Kjeldsen et. al., 1997).

The sites around Webb Tract were selected because they were in public ownership and as shown in the Webb Tract inventory Appendix A, they represented different types of in-channel islands and they are influenced by different physical forces. The candidate islands were then nominated and approved by the Delta In-channel Islands Workgroup at the May 15, 1997, meeting. Four study sites were selected for the demonstration project. One site was eliminated due to the large size of the candidate in-channel island and the resulting high projected costs for installation of the biotechnical wave and erosion control structures. The selected sites are all distinctly different physically and biologically and offer a range of opportunities for demonstrating different techniques for stabilizing and recovery of in-channel islands. Two of the sites are located around Webb Tract and are owned by the California Department of Fish and Game (DFG). These are unnamed islands and are referred to as Webb Tract I and III. The third site is known as Little Tinsley Island, owned by the Noble Yacht Group with a Conservation Easement held by DFG. Little Tinsley Island as an in-channel island was created by the dredging of the Stockton Deep Water Shipping Channel which separated it from Big Tinsley Island.

The three study sites are:

- 1). A peat island that has a high degree of human use and impact, Little Tinsley Island,
- 2). A subtidal shoal supporting two patches of California Bulrush (*Scirpus californicus*) that is rapidly disappearing along the San Joaquin River on the north side of Webb Tract, Webb I, and
- 3). A peat island along the south side of Webb Tract that has an elevation high enough to support riparian vegetation including willow (*Salix* ssp.) button-willow (*Cephalanthus occidentalis* var. *californicus*) and white alder (*Alnus rhombifolia*).

Characteristics of each of the study sites are summarized in Table I below.

**Table I. Summary of Conditions at In-Channel Island Study Sites**

| <b>PROJECT SITE NAME</b>                 | <b>Adjoining Waterways</b>       | <b>Distance From Levee</b>            | <b>Vegetation Type</b> | <b>Riverine Aquatic Bed</b>          | <b>Acreage Length &amp; Width Acres</b> | <b>Elevation from + or - MLLW</b> |
|--|----------------------------------|---------------------------------------|------------------------|--------------------------------------|---|-----------------------------------|
| <b>Webb Tract I Submerged Shoal</b>      | Stockton Deep Water Ship Channel | Webb Tract 290 ft.                    | PEM or R2EM            | Around Perimeter Extends at each end | 250' x 30' 0.17 Ac.                     | -0.7 ft.                          |
| <b>Webb Tract III Peat Island</b>        | False River                      | Webb Tract 312 ft.                    | PEM or R2EM PSS1 PFO1  | Around Perimeter                     | 490' x 35' 0.39 Ac.                     | + 3.0 ft.<br>+ 2.0 ft.            |
| <b>Little Tinsley Island Peat Island</b> | Stockton Deep Water Ship Channel | Empire 440 ft.<br>Big Tinsley 400 ft. | PSS1 PFO1              | South Side East End and North Side   | 1,168' x 321' 4.3 Ac.                   | +4.0 ft.                          |

PEM= Palustrine Emergent Vegetation, R2EM=Riverine Emergent Vegetation, PSS1= Palustrine Shrub/scrub, PFO1= Palustrine Forest.

Consultation and a site visit with representatives from The U. S. Army Corps of Engineers (ACOE) Water Ways Experiment Station (WES) provided input for the design criteria.

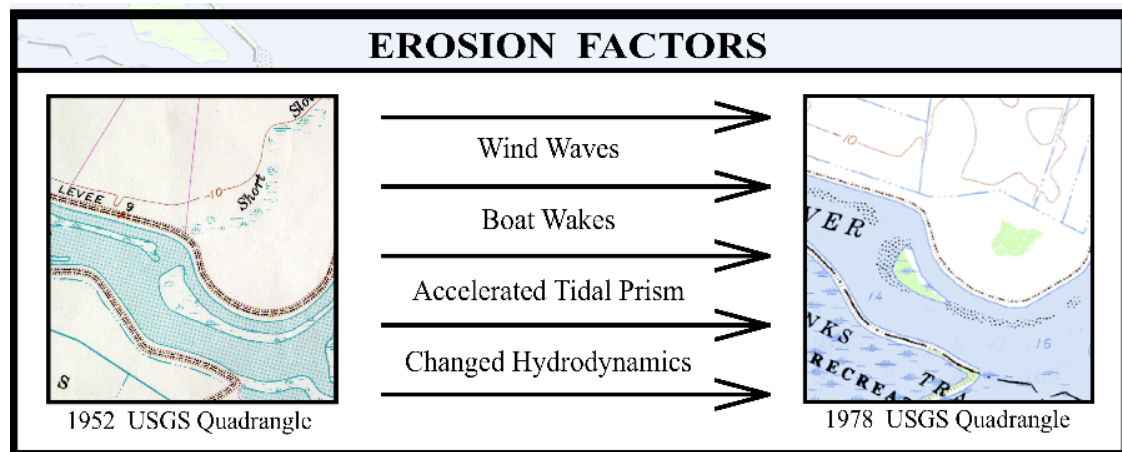
Construction of the biotechnical wave and erosion control structures was completed on Webb Tract III in October 2000 and vegetation planting was completed in 2001, (adaptive management resulted in the abandonment of Tethered Log Booms and the development of Anchored Mulch Pillow Mats ("Mulch Pillows") for planting of tule or California bulrush stock (*Scirpus californicus*) in fall 2002). Treatments were installed on Little Tinsley Island in November 2001.

Construction was completed on Webb Tract I in August 2002, and adaptive management lead to the installation of ballast buckets replacing the degraded mulch pillows in the fall of 2003.

The construction for the Amendment (Anchored Woody Debris Pile) on Webb III was initiated in 2004 and completed in 2005.

## 1.2 Conceptual Model

The dynamic equilibrium of the Delta pre-1850 has been lost. Hydrology has been altered in timing as well as diminished. Sediment input has been greatly interrupted by dams positioned low on all of the major tributaries, trapping most sediment that was moving downstream. Tule (*Scirpus* spp.) growth and biomass “peat” accumulation has diminished and as a result the stability and accretion of the in-channel islands of the Western Delta is being compromised. Levees and bank protection reduce the lateral erosion of the river channels in the valley floor reaches. The Delta itself has been largely diked and channeled. Boat wakes today add an erosive force not seen earlier. To counter erosion of ICIs, a variety of measures are useful. Some measures are considered “hard” and deleterious to aquatic resources; examples are riprap and bulkheads. Some measures are considered “soft” and neutral to advantageous to aquatic resources; examples include Floating Log Breakwaters, Brush Walls, shrub plantings, Rootwads, etc. Each treatment is designed to address the hydraulic forces affecting ICI erosion. “Wave Breakers” dampen (reduce height) and buffer (reduce force) of waves in the upper water column. Brush Walls and “curtains” act as breakwaters for lower water column currents. Groins or peaked stone dikes deflect tidal currents. Large Rootwads act as breakwaters and provide toe protection. Collectively biotechnical measures can protect ICIs from further erosion for an interim period and in some local situations may catch and accrete sediments to the ICI. A suite of measures can be used in a coordinated fashion to protect the island and improve habitat values for target fish and wildlife species.



**Figure 2.** Summary of erosion factors that impinge on the developed biotechnical structures. Note the loss of in-channel habitat from 1952 to 1978.

In the longer term, the basic purpose of the biotechnical treatments proposed (see Table II below) for this project is to protect the shorelines of the ICIs from erosive forces for a sufficient duration to allow native emergent wetland and woody riparian vegetation to become established. Established vegetation will protect the shoreline from erosion in several ways: leaves and stalks slow currents and lessen wave energy; elastic deformation of emergent plants dissipates wave energy; emergent plants lie flat with currents and waves providing cover for the soil; dense fibrous emergent root systems enclose and consolidate sediments; deep tangled roots of woody plants reinforce soil from the shear forces of currents and

waves and restrain and filter soil particles; and woody trunks provide soil arching restraint and buttressing (Gray and Leiser1982, Goldsmith and Bestmann 1992). Once the protected plantings become established, hydraulic roughness on a micro-scale will increase and effectively trap fines from suspended load. DCI's hydrogeomorphology consultant (Swanson Hydrology and Geomorphology) has experience modeling the dynamics that drive this process on ICIs.



**Figure 3.** Tule mass that has been eroded off and is floating in mid channel.



**Figure 4.** Boat wakes along the shore of an in-channel island.

**Table II. Summary of Biotechnical Wave and Erosion Control Treatments**

| <b>TYPE OF BIOTECHNICAL STRUCTURE</b>         | <b>DESIGN FUNCTION</b>  | <b>COMPOSITION</b>   | <b>SITE</b>                    | <b>LINEAR FEET</b>                      |
|---|---|--|--------------------------------|---|
| <b>Brush Walls</b>                            | Natural Breakwater  | Dead branches, 4-inch wooden posts, galvanized wire  | Webb Tract III, Little Tinsley | 400 l.ft. (WT III)<br>500 l.ft. (LT)    |
| <b>Log Wave Breaker Design #1</b>             | Wave/wake dampening and buffering   | 12 to 16-inch wooden posts, galvanized all-thread bolts, washers and nuts. Retrofitted in 2002                       | Little Tinsley,                | 430 l.ft. (LT),                         |
| <b>Log Wave Breaker Design #2</b>             | Wave/wake dampening and buffering   | Retrofitted in 2002<br>Additional logs retrofitted into gaps to prevent waves from passing through                   | Little Tinsley,                | 430 l.ft. (LT)                          |
| <b>Buttressed Log Wave Breaker Design # 3</b> | Wave/wake dampening and buffering   | 12 to 16-inch wooden posts, galvanized all-thread bolts, washers and nuts, double piling with buttress support       | Webb Tract I                   | 270 l.ft. (WT I)                        |
| <b>Small Log Wave Breaker</b>                 | Wave/wake dampening and buffering   | “ Peeler Poles” as piling and cross braces, galvanized all-thread bolts, washers and nuts.                           | Little Tinsley                 | 24 l.ft. (LT)                           |
| <b>Rootwad Wave Breaker</b>                   | Wave/wake dampening and buffering   | 6-inch wooden posts, galvanized all-thread bolts, washers and nuts, apple tree stumps and roots                      | Little Tinsley Island          | 110 l.ft. (LT)                          |
| <b>Large Anchored Rootwad</b>                 | Toe protection natural breakwaters, current deflectors, 3-D aquatic habitat | Eucalyptus tree stumps and roots, galvanized cable, couplings and deadman anchors                                    | Webb Tract III                 | 795 l.ft. (WT III)                      |
| <b>Peaked Stone Dike or Groin</b>             | Current deflection, break-water   | Rock (mixed sizes)   | Webb Tract III, Webb Tract I   | 285 l.ft. (WT III),<br>255 l.ft. (WT I) |
| <b>Floating Log Boom</b>                      | Wave/wake dampening and buffering, aquatic habitat                          | 12” logs and galvanized all-thread bolts, washers and nuts, 16” hollow steel pilings, galvanized cable and couplings | Webb Tract III                 | 155 l.ft. (WT III)                      |

| TYPE OF BIOTECHNICAL STRUCTURE                         | DESIGN FUNCTION   | COMPOSITION  | SITE           | LINEAR FEET                |
|--|---|--|----------------|----------------------------|
| <b>Ballast Buckets</b>                                 | Plant protection, aquatic habitat                                   | 7" X 7" and 15" X 10" biodegradable pulp plant containers filled with sand, gravel, and clay   | All            | 1240 containers (WT III)   |
| <b>Floating Log Planter with Mulch Pillows</b>         | Tule Island establishment   | Bound and tethered log boat planted 20' x 4' with Mulch Pillows for <i>Scirpus</i> planting.   | Webb Tract I   | 30 l.ft. (WT I)            |
| <b>Floating Log Planter with Ballast Buckets</b>       | Tule Island establishment   | Bound and tethered log boat planted 20' x 4' with ballast buckets for <i>Scirpus</i> planting. | Webb Tract I   | 30 l.ft. (WT I)            |
| <b>Mulch Pillows</b>                                   | Tule planting Substrate   | Mulch pillows pinned down and planted  | Webb Tract III | @ 40 feet (WT III) & WT I) |
| <b>Anchored Woody Debris Pile (Amendment Proposal)</b> | Wave/wake dampening and buffering, aquatic habitat, and avian perch | Piling with woody debris lashed together and anchored to 16" hollow-steel pilings              | Webb Tract III | 155 ft. by 25 ft. (WT III) |

### 1.3 Objectives

Monitoring for the project is based on the Monitoring Plan submitted by Delta In-Channel Island Workgroup (DICIW) and updated by CALFED (2002). The project has two objectives and tests seven hypotheses. The two objectives of the project are:

**Objective 1:** to demonstrate that the erosion of in-channel islands can be slowed, stopped, or reversed using bio-engineered ecosystem restoration technologies is summarized by the following three hypotheses:

Hypothesis 1A: Hydrodynamic energy can be dissipated by installing appropriate biotechnical methods along shores.

Hypothesis 1B: In-channel island substrate can be conserved and/or accreted using biotechnical methods.

Hypothesis 1C: Biotechnical methods offer stable, long-term protection against erosion.

**Objective 2:** to demonstrate that bio-engineered ecosystem restoration technologies can be successfully installed with positive effects on important/priority fish, wildlife and plants is summarized by the following four hypotheses:

Hypothesis 2A: Habitat protected by biotechnical wave and erosion control methods will benefit priority fish species.

Hypothesis 2B: Biotechnical wave and erosion control treatments will protect and benefit terrestrial biota.

Hypothesis 2C: Vegetation establishment along island edges (shoreline) will be enhanced by biotechnical wave and erosion control methods.

Hypothesis 2D: Non-native invasive plant or animal species will not benefit from the wave and erosion control methods.

**The monitoring plan is based on:**

- CALFED monitoring criteria and PSP;
- The Project CALFED's Phase II Proposal;
- An "adaptive management" monitoring plan with periodic annual review and analysis of monitoring criteria to modify or continue the monitoring program; and
- Standard Operating Procedures and Performance Standards.

The Tables III and IV below summarize the hypotheses being tested, the monitoring parameters and data evaluation for the two objectives.

**Table III. Objective 1: to demonstrate that the erosion of the Delta's in-channel islands can be slowed, stopped or reversed using appropriately engineered biotechnical methods.**

| <b>HYPOTHESIS</b>   | <b>MONITORING<br/>PARAMETER</b>                             | <b>DATA EVALUATION</b>  |
|---|---|---|
| <b>1A: Hydrodynamic energy can be dissipated by installing appropriate biotechnical methods along shores.</b> | Empirical observations and water/wave current measurements. | Visual and photographic documentation of wave or current dissipation on treated and untreated areas. Pre- and post- current measurements and evaluation of impact on surrounding areas. |
| <b>1B: In-channel island substrate can be conserved and/or accreted using biotechnical methods.</b>           | Field mapping   | Changes in elevation will be compared with adjacent untreated sites.  |
| <b>1C: Biotechnical methods offer stable, long-term protection against erosion.</b>                           | Empirical observation                                       | Visual documentation from fixed photopoints comparing treated and untreated areas over time.  |

**Table IV. Objective 2: To demonstrate that biotechnical erosion control methods can be successfully installed with positive effects on important/priority fish and wildlife.**

| <b>HYPOTHESIS</b>  | <b>MONITORING<br/>PARAMETER</b>   | <b>DATA EVALUATION</b>  |
|--|---|---|
| <b>2A: Habitat protected by bio-technical erosion control methods will benefit priority fish species.</b>              | Pre- and post- project fisheries monitoring will be performed using appropriate methods approved by regulatory agencies.          | Seasonal census of priority fish populations associated: 1) around the project islands and, 2) within the biotechnical structures and vegetation. |
| <b>2B: Biotechnical methods will protect and possibly benefit terrestrial biota.</b>                                   | Pre- and post- project monitoring of selected terrestrial biota using appropriate methods.  | Wildlife utilization of biotechnical structures.<br>Differences in percentages of native vegetative cover.  |
| <b>2C: Vegetation establishment along island edges will be enhanced by biotechnical erosion control methods.</b>       | Vegetation succession: riverine emergent, riverine aquatic bed, shaded riverine aquatic habitat quantification and qualification. | Pre- and post- project analyses of vegetation populations.<br>Visual documentation from fixed photopoints   |
| <b>2D: Non-native invasive plant or animal species will not benefit from the biotechnical erosion control methods.</b> | Pre-and post- project monitoring of non-native invasive species.  | Change in non-native plant or animal species composition.   |

### 1.3 Schedule

Monitoring for Webb Tract I, Webb Tract III, and Little Tinsley Island took place once in the spring and once in the fall for each island for three years, except Webb Tract I, which was monitored for only two years because of the later construction schedule. The 2005 monitoring was limited to the fall with review in February of 2006.



## **2.0 BIOLOGICAL METHODS**

Project performance was addressed by evaluating each of the above hypotheses with ongoing monitoring activities. This section presents the monitoring methods for wildlife and vegetation, as well as photomonitoring. The photo log is presented in Appendix A.

### **2.1 Wildlife**

Wildlife monitoring was conducted in the fall and spring of 2002 and 2003, and in the spring of 2004 to record the presence of avifauna, mammal, and amphibian species on the project sites. A take permit for salmon and smelt could not be obtained for the monitoring so no aquatic surveys for fish species were conducted. Wildlife surveys were conducted after the installation of engineered wave and erosion control methods on Little Tinsley Island and Webb Tract III. Monitoring on Webb Tract I began in 2003.

#### **Purpose**

The purpose of wildlife monitoring is to compare the baseline biological use by wildlife species at the pre-construction ICIs and the post-construction ICIs as described in the following two hypotheses:

Hypothesis 2B: Biotechnical wave and erosion control treatments will protect and benefit terrestrial biota.

Hypothesis 2D: Non-native invasive plant or animal species will not benefit from the biotechnical wave and erosion control treatments.

#### **Survey Protocol and Methods**

Wildlife monitoring addressed bird utilization, wildlife utilization, and the assessment of special status species associated with each island, if any. Wildlife observations were recorded

for two hours during morning hours (dawn) and for two hours during evening hours (dusk) at each island. Field observations were primarily made by kayak (or by power boat without using the engine), enabling the investigators to approach quietly and easily maneuver around the island. Species occurrence was recorded by behavior activity class (forage, nest, react, roost, song, swim, or flyover). Monitoring events required two or more field biologists per visit to ensure safety and allow improved data collection. Field biologists (Daniel T. Kjeldsen and Katherine Kobrin conducted monitoring in 2002 and 2003 and Daniel T. Kjeldsen and Chris K. Kjeldsen) recorded observations in field books and standardized data sheets.

Data collection techniques followed protocol established by pre-construction monitoring (Kjeldsen et al. 1997) and present the general wildlife utilization of the islands. Observations were not specific to monitoring points and were generally applicable to each island in its entirety. In addition, while field biologists made an effort to select moderate tides and fair weather, tide and weather conditions may have affected the outcome of monitoring events.

When flocks of birds numbering more than 25 were observed, they were recorded as abundant in the field forms. Flyovers were recorded only when birds flew over a portion of the island. Birds using the channel were not recorded. Birds were recorded in only one category to limit the amount of double counting.

Species were identified by either direct observation (with the aid of binoculars), or indirect evidence including vocalization and behavior. Behavior of the species observed at first encounter by the observer was recorded. Seven behavioral activity classes were recorded. These activity classes represent a slight modification to activity categories used by England and Naley (1990) as defined below:

Forage: actively foraging species including aerial foraging by swallows and phoebes, and foraging within shallow water habitat associated with a candidate island by herons and ducks;

Nest: evidence of nesting including abandoned nests, gathering of nesting material, brooding, incubating, etc.;

React: behavior resulting from the presence of an observer;

Roost: resting, roosting, quietly perched, or preening;

Sing: singing or actively defending a territory;

Swim: moving through the water, not in response to observer; and

Flyover: flying by or over a candidate island in transit to another area

### **Species of Concern**

Analysis of utilization of the near shore environment or upland by any special status animal species is included in Hypotheses 2A and 2B (DICIW, 2002). Any occurrence of special status species within the monitoring units was included in quantitative analysis of percent cover by species. Occurrence of special status species outside monitoring units were noted and counted, if possible. No “take” was proposed or conducted. As intended, monitoring was non-destructive.

### **Vegetation Monitoring**

Vegetation monitoring was conducted in Spring and Fall of 2002, 2003, 2004 and fall of 2005 to record the presence of special-status species, non-native invasive species colonization, establishment of vegetation plantings, natural colonization, and vegetation cover behind the various biotechnical wave and erosion control structures. Monitoring units were established for the biotechnical wave and erosion structures or combination of structures. Adaptive management protocols have been initiated based on vegetation surveys.

## **Purpose**

The purpose of vegetation monitoring was to compare plant cover and diversity affected by biotechnical wave and erosion control methods as described in the following two hypotheses:

Hypothesis 2C: Vegetation establishment along island edges (shoreline) will be enhanced by biotechnical wave and erosion control treatments.

Hypothesis 2D: Non-native invasive plant or animal species will not benefit from the biotechnical wave and erosion control treatments.

## **2.2.2 Survey Protocol and Methods**

Vegetation monitoring for Webb Tract I, Webb Tract III, and Little Tinsley Island was conducted in the spring and fall for years 2002, 2003, 2004 and the fall of 2005. Vegetation monitoring was conducted by Kjeldsen Biological Consulting (Chris K. Kjeldsen and Daniel T. Kjeldsen) and LFR (Richard Nichols, Katherine Kobrin, and Ryan LaFrenz-2002, by Chris K and Daniel T. Kjeldsen 2003 and 2004 and by Chris K and Daniel T. Kjeldsen and Richard Nichols 2005).

Vegetation monitoring addressed the survivorship and percent cover of planted and naturally regenerating California bulrush stock (*Scirpus californicus* and *S. acutus*) and behind the biotechnical wave and erosion control structures. Percent cover of species of emergent and submerged vegetation (to quantify vegetation recovery and succession, and species diversity) was also recorded for the intertidal bare mud zone or the area behind the installed structures. Our monitoring also included an assessment of non-native vegetation cover. In addition, an assessment of special status species associated with each island was conducted.

Monitoring focused on the emergent aquatic vegetation of the shoreline behind the treatments because the vegetation on the upland areas should remain consistent. Vegetation monitoring was conducted by field biologists familiar with the local vegetation, and was executed using kayaks and/or powerboats. Monitoring events required two or more field biologists per visit to ensure safety and allow improved data collection. Field biologists recorded observations in field books and standardized data sheets, and photographed established photomonitoring points within each monitoring unit. Vegetation monitoring was coordinated with low tides. Photography of vegetation may vary because of differences in tide during separate monitoring events.

Each treatment site was identified based on the biotechnical wave and erosion control structures and separated into monitoring units. Webb Tract I was made into one unit in its entirety and the Tethered Floating Log Planter treated separately; Webb Tract III was divided into six units; and Little Tinsley Island was divided into eight units. Each monitoring unit was mapped (Figures 1, 2 and 3) and was easily identifiable by treatment type and land features.

During monitoring, vegetation within each monitoring unit was quantified by percent cover by species using visual estimation techniques by two investigators. Cover in the entire unit

was recorded, including bare ground and open water. The occurrence of non-native species and special status species was recorded (within and outside the monitoring unit). Planted stock was counted to assess survival, with a record of notable mortality. Plant stock survival is currently being reviewed. Additional plant stock may be planted to assess new experimental techniques; therefore, numbers of surviving plant stock may vary from year to year dependent upon continued plantings and will not necessarily reflect total survivorship of initial plantings.

### **Species of Concern**

Analysis of change of area covered by special status plant species is included in Hypothesis 2C (DICI 2002). Any occurrence of special status species within the monitoring units was included in quantitative analysis of percent cover by species. Occurrence of special status species outside monitoring units (such as Suisun marsh aster, which occurred on the bank adjacent to monitoring units) was noted and counted, if possible. No “take” was proposed. As intended, monitoring was non-destructive.

Five special status plant species were identified during baseline analysis of the islands (Kjeldsen et al. 1997): Mason’s lilaeopsis (*Lilaeopsis masonii*; federal species of concern, state rare plant, CNDDDB ranked as threatened); Delta tule pea (*Lathyrus jepsonii* var. *jepsonii*; federal species of concern, CNDDDB ranked as threatened); Delta mudwort (*Limosella subulata*; CNDDDB ranked as very threatened); elderberry (*Sambucus mexicana*; habitat for the federally threatened valley elderberry longhorn beetle); and California hibiscus or rose-mallow (*Hibiscus lasiocarpus*; CNDDDB ranked as threatened). In addition, Suisun marsh aster (*Aster lentus*; federal species of concern, CNDDDB ranked as threatened) has been identified as a special status plant occurring on the islands.

### **Non-Native Species**

If non-native plant species become established, they can compete with native species for light, moisture, and nutrients. Because biotechnical wave and erosion control structures stabilize habitat, the project may provide an opportunity for invasion by non-native species. It would be desirable to know whether the biotechnical wave and erosion control methods favor or enhance the development of non-native species. Analysis of change of area covered by non-native plant species is included in Hypothesis 2D (DICI 2002).

Several non-native invasive plant species have been found to occur on the islands. Non-native terrestrial plant species include pampas grass (*Cortaderia selloana*), iris (*Iris pseudoachoris*), dock (*Rumex* sp.), purple loosestrife (*Lythrum salicaria*), Himalayan blackberry (*Rubus discolor*), bindweed (*Convolvulus* sp.), and annual grasses. Non-native aquatic plant species include water hyacinth (*Eichhornia crassipes*) and waterweed (*Egeria densa*). Little Tinsley Island has been partially developed by the Noble Yacht Club; it is probable that is the reason it also supports several ornamental non-native species. Water hyacinth (*Eichhornia crassipes*) is the most common non-native plant species found within monitoring units. During our 2003 field monitoring we observed a state agency spraying for water hyacinth near our study units.

## **2.3 PHOTOMONITORING STATIONS**

Photomonitoring stations were established in the pre-project baseline study to provide an overview of the project. Additional photomonitoring stations have been established for each biotechnical wave and erosion control treatments as separate monitoring units.

## **Methods**

Photomonitoring in the 1997 pre-project baseline study used slide and print film. These were photographs from different sectors that provided an overview of the pre-project conditions. The first annual report includes replica post project photographs. We have found that these photomonitoring stations do not reveal details that are critical for the project. New photomonitoring stations were established for each of the treatment units in 2002 and replicated in 2003, 2004 and 2005. The Photomonitoring for the project was conducted using digital cameras. In addition to the photographs, video monitoring was conducted during the construction phase of the project on Webb Tract 3 in October 1998 and during the hydrodynamic investigations on July 4, 2002 by Richard Nichols, LFR.

## **Fisheries**

Analysis of fisheries habitat is included in Hypothesis 2A and 2D (DICIW 2002). Monitoring of the benefit of biotechnical wave and erosion control methods to priority fish species may be conducted in coordination with an appropriate agency. If and when performed, monitoring could include electroshocking conducted by a CDFG representative holding an Endangered Species Act Section 10(a)(1) take permit. It may also be worthwhile to monitor angling success at project sites to determine catch species. Intense angling pressure often indicates an abundance of non-native sport fish (striped and largemouth bass).

At the time of this report, aside from indirect observations associated with other monitoring efforts (fish jumping during wildlife monitoring periods), no methods are in place to monitor habitat for the presence or absence of fish. However, DICIW staff will consider recent findings presented at the CALFED Science Conference related to fish usage of near-shore habitat in the Delta. These findings may dictate, without actual sampling, what fish species are expected to use the project habitat.



## **3.0 HYDRODYNAMIC METHODS**

The project, as a pilot study, is intended to provide designs for biotechnical wave and erosion control treatments for the conditions of the Delta that will control or mitigate for wave and current generated erosional forces. The hydrodynamic monitoring is an integral part of the monitoring protocol. Hydrodynamic monitoring was part of the first annual report. A copy of this report is included as an appendix in the first three annual reports. This study was conducted by Swanson Hydrology and Geomorphology.

### **3.1 Purpose**

The purpose of hydrodynamic forces monitoring was to assess the performance of treatment structures in response to impacts from recreational boat wakes to test the following three hypotheses:

Hypothesis 1A: Hydrodynamic energy can be dissipated by installing appropriate biotechnical treatments along shores.

Hypothesis 1B: In-channel island substrate can be conserved and/or accreted using biotechnical treatments.

Hypothesis 1C: Biotechnical wave and erosion control treatments offer stable, long-term protection against erosion.

### **3.2 Survey Protocol and Methods**

Field monitoring was conducted at two sites during the July 4th and Labor Day holidays during peak boat use periods: Webb Tract III and Little Tinsley Island. The primary focus

was the performance of the structures in response to boat wake wave energy, their ability to protect the in-channel islands from erosion, and their durability. The dates were also selected to document wave conditions during spring and Neap tidal conditions. The structures monitored are listed on Figure 5 and include Rootwad Wave Breaker, placed Large Anchored Rootwads, Brush Walls, and Log Wave Breakers. Wave height data was collected outboard and inboard of the structures to document the reduction of wave height and energy as a wave passes through the structure. Staff plates were set up in board and out board and video was continuously taken. Because wave movement was in trains of multiple waves and too rapid to gain reliable results from simple field observation, the video was time stamped and taken back to the office where wave heights were recorded using slow motion video. Please see the Appendix for a detailed discussion of the supporting data and results.

The averaged results show that Brush Walls were the most effective in reducing wave energy and they also appeared to be the most durable structures. Log Wave Breakers were the second most effective structures; however, they were found to be susceptible to damage and require maintenance. Rootwad Wave Breaker were the third most effective structures and Large Anchored Rootwads were fourth; both exhibited greater porosity than Brush Walls and have been significantly modified due to wave action.

Hydrodynamic monitoring results indicate biotechnical treatments reduce wave height by 35%-64% and reduce wave energy by 57%-87%.

A copy of the full report is included as an Appendix in Reports One to Three.



## 4.0 BIOLOGICAL RESULTS

This section presents the results of biological monitoring for 2005 and analysis of results from the inception of the project with comparison to baseline studies conducted in 1997. For the analysis of results from year one (2002), year two (2003) and year three (2004) please refer to the previous annual reports. Monitoring for the amendment was not made since the project installation was completed after the monitoring event. The 2005 monitoring was conducted on October 14, 2005 (a follow up site review was conducted on February 22, 2006).

### 4.1 Webb Tract I

Webb Tract I is a submerged subtidal island or shoal with California bulrush (*Scirpus californicus*) and a surrounding riverine aquatic bed. This island/shoal is along the deepwater-shipping channel. Construction of the biotechnical wave and erosion control structures was completed in fall of 2002 and monitoring for Webb Tract I began in spring 2003. The monitoring units for Webb Tract I are shown on Figure 2.

This study site is in an exposed situation with an expanse of open water to the northwest which is the direction of prevailing winds. The Buttressed Log Wave Breaker (design # 3) is constructed to protect the site from wave action from this direction. The strong Delta storm waves generated from south winds are assumed to be minimized by the short fetch between the site and the levee of Webb Tract.

A new design structure was implemented in the construction of the Buttressed Log Wave Breaker that was based on the findings from the Log Wave Breaker at Little Tinsley Island. The changes are use of four pilings, instead of two pilings at the point where logs are secured, a contiguous wall of logs as per the retrofitted design of Little Tinsley, and a buttress log support on the backside of the Buttressed Log Wave Breaker.

A second design structure that is new for the project was a Floating Log Planter with Mulch Pillows that were planted with *Scirpus*. The Mulch Pillows washed out with wave action during the first winter. It is suspected that refraction occurs of northwest wind generated waves over the long fetch in this area of the channel (see the Wind Roses for this area of the Delta in the Baseline Study). The Mulch Pillows have been replaced with Ballast Buckets planted with *Scirpus*. The design of this structure is such that as *Scirpus* growth is initiated and the logs become waterlogged the unit will sink with time and the *Scirpus* will continue to grow and root at the bottom of the channel. This structure is designed to test the concept of increasing the area of a tule shoal.

#### **4.1.1 Wildlife Webb Tract I**

Wildlife monitoring for this site began in 2003. Monitoring found that river otter utilized the Floating Log Planter and ample evidence of bird utilization of the structure as shown on the cover of the 2004 report.

#### **4.1.2 Vegetation Webb Tract I**

Vegetation monitoring began on this site in 2003. Monitoring showed an increase of the tule bed that characterized this shoal. The fall 2005 monitoring found a 7% increase in total cover as a result of tule growth over the duration of the project as shown in Table XV.

The Floating Log Planter design was altered and converted from mulch pillows to planted ballast buckets which support tule growth. The estimated percent cover for this treatment was 19% total *Scirpus* cover in October of 2005.

### **4.2 Webb Tract III**

Webb Tract III is an organic “peat” island that is exposed to the wave fetch from Franks Tract and to strong tidal currents from an enhanced tidal prism as a result of the large expanse of open water at Franks Tract (incoming on the west end and outgoing on the east end). The monitoring units for Webb Tract III are shown in Figure 3. The results of wildlife and vegetation monitoring are presented below.

#### **4.2.1 Wildlife Webb Tract III**

The results of wildlife monitoring comparing baseline to 2002, 2003 and 2004 are presented in Table V below.

**Table V.** Analysis of Change in Terrestrial Biota Utilization of Webb III Habitat

| <b>MONITORING SEASON WEBB III</b> | <b>BIRD SPECIES INCLUDING FLYOVER</b>      | <b>MAMMAL</b>        | <b>BIRD SPECIES EXCLUDING FLYOVER</b> |
|-----------------------------------|--|----------------------|---------------------------------------|
| <b>1997 Baseline Study</b>        | 13   | 2-Beaver and Muskrat | 12                                    |
| <b>2002 Sp and Fall</b>           | 23   | 1                    | 13                                    |
| <b>2003 Sp and Fall</b>           | 17   | 1                    | 14                                    |
| <b>2004 Spring only</b>           | 16   | 2-Beaver and Raccoon | 11                                    |
| <b>Ave Change from Baseline</b>   | Increase of 5.6 for the monitoring period. |                      | Increase of 0.6 for monitoring period |

**Analysis of change in mammal utilization of island habitat.** Beavers were observed on Webb Tract III in 2002 and in 1997. Beavers were not observed during the monitoring of 2003 but were observed in 2004 (a pair). A foraging raccoon was observed during the spring 2004 monitoring.

**Analysis of change in bird utilization of island habitat.** Monitoring found an increase in bird species associated with the study sites over the base line study. It is suggested that the increased utilization is a result of the structure for perch provided by the biotechnical structures.

There has been an increase in the number of bird species utilizing Webb Tract III as compared to the baseline study. We suspect that the biotechnical wave and erosion control structures increase the diversity of the island thus contributing to the change in numbers. On Webb Tract III, there were no observed non-native animal species benefiting from the installation of the biotechnical wave and erosion control devices.

We have found that wildlife monitoring using the standard protocol established in the Baseline Study is variable depending on weather conditions. On windy days the birdlife, which is the primary indicator, is low. The data presented above although variable indicates that the biotechnical structures are not having an adverse effect on wildlife utilization of the study sites and contribute to a slight increase in bird utilization.

Table VI below presents a comparison of avifauna utilization of Webb Tract III, excluding flyover for the duration of monitoring as compared to the 1997 Baseline Study. The results indicate that although there is variation there is an increase in perch or roosting on the island. The difference in song calls is interesting but no conclusions can be drawn (the pre-project monitoring was conducted by different investigators and spring only over several monitoring periods).

**Table VI. Avifauna Utilization of Webb III.**

| <b>MONITORING<br/>SEASON WEBB<br/>TRACT III</b> | <b>FORAGE</b> | <b>NEST</b> | <b>REACT</b> | <b>ROOST</b> | <b>SONG</b> | <b>SWIM</b> |
|---|---------------|-------------|--------------|--------------|-------------|-------------|
| <b>1997 Baseline Study</b>                      | 35%           | 0           | 7%           | 7%           | 40%         | 7%          |
| <b>2002</b>                                     | 41%           | 6%          | 6%           | 41%          | 6%          | 0           |
| <b>2003</b>                                     | 35%           | 0%          | 5%           | 54%          | 6%          | 0           |
| <b>2004</b>                                     | 34%           | 0%          | 0%           | 34%          | 12%         | 0           |
| <b>Average change from<br/>Baseline Study</b>   | +2            | +2          | -3           | +36          | -32         | -7          |

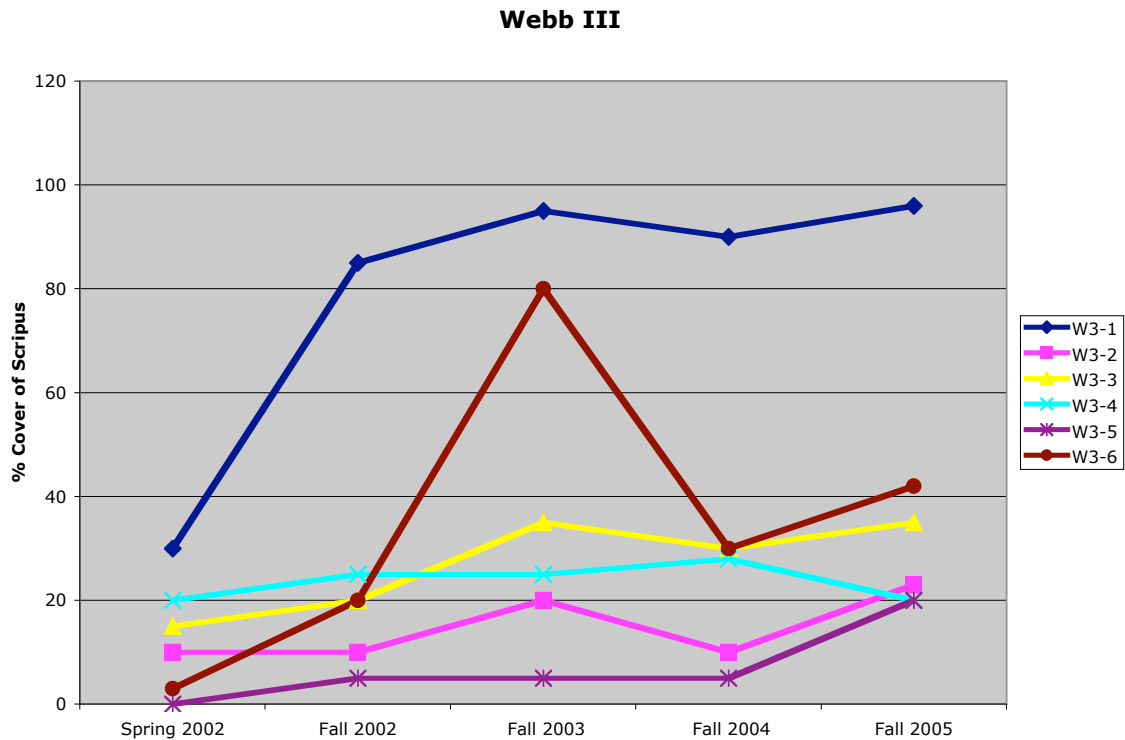
#### **4.2.2 Vegetation Webb Tract III**

The six monitoring units for Webb Tract III (Figure 3) were measured twice during 2002 and 2003 and once in 2004 and 2005. The first monitoring event took place on March 8, 2002, (Spring) and the second took place on September 19, 2002 (Fall). The 2003 monitoring was conducted April 9, 2003, and September 24, 2003. The 2004 monitoring was completed on June 23, 2004 and the 2005 monitoring was conducted on October 14<sup>th</sup>.

Survey results are presented on data sheets included in the Appendix of this report. The aerial layout of the monitoring units was standardized. Photographs of monitoring units are included in the Appendix of this report. During the spring monitoring event, photographs were taken landside. Protocol was standardized after that time so that all photographs of monitoring units will be taken waterside. Photomonitoring locations are shown on Figure 3. Tables VII and VIII compare initial monitoring in 2002 to the final monitoring in 2005.

**Percent Cover.** The amount of vegetative cover increased from 2002 to 2005 within all monitoring units except for Webb Tract III 3 where Large Anchored Rootwads were installed. We note that when all of the monitoring units are averaged and compared to the 2002 data that the 2005 monitoring shows an increase in total vegetation cover for the island behind the biotechnical structures.

**Scirpus Cover.** Tule coverage was estimated including both endemic common tule (*Scirpus acutus* var. *occidentalis*) and the planted California bulrush (*Scirpus californicus*) (See Figure 5 and Tables VII and VIII). The cover of tules behind the monitoring units increased within all monitoring units when the 2002 data is compared to the results of monitoring in 2005. The change in tule cover as shown in Table XV ranges from no detectable difference (note that there was no loss indicating that the structure stabilized the site) to a 66 % increase over the duration of the monitoring. This demonstrates the effectiveness of the biotechnical structures in supporting the establishment, recruitment and or expansion of existing tules when given wave and erosion protection. The relevance of this is enhanced by the recognition of the role that tules play as ecosystem engineers in this environment.



**Figure 5.** Percent area occupied by tules behind the monitoring units on Webb Tract III. The data is comparing spring 2002 monitoring to fall 2005 monitoring.

**Survivorship of Planted Stock.** During fall monitoring, vegetation appeared robust; mortality of planted stock appeared to be insignificant. It was difficult to assess success of individual plantings because of the generally uniform overall increase of tule cover. In addition, new plantings were taking place on Webb Tract III -6 at the time of the 2004 fall monitoring. Numbers of surviving plant stock may vary from year to year dependent upon continued plantings and will not necessarily reflect total survivorship of initial plantings.

**Special-status Species.** A highly notable voluntary recruitment of both Suisun marsh aster (*Aster lentus*) and Mason's lilaeopsis (*Lilaeopsis masonii*) occurred on Webb Tract III. Suisun marsh aster (*Aster lentus*) occurred on the bank bordering monitoring units. Individual plants of (*Aster lentus*) were counted.

Mason's lilaeopsis (*Lilaeopsis masonii*) occurs in sun-exposed intertidal areas within monitoring units. Percent cover was assessed as shown in Table VII below. Significant increases were observed as shown in Table VII. In addition, we observed colonization of Mason's lilaeopsis (*Lilaeopsis masonii*) on several Large Anchored Rootwads in the intertidal zone.



**Figure 6.** Mason's Lilaeopsis (*Lilaeopsis masonii*) growing behind brush wall on Webb III.

**Non-native Species.** Non-native plant species occurring on the island upland of the monitoring units included purple loosestrife, pampas grass, bindweed, and annual grasses. Water hyacinth (*Eichhornia crassipes*), water-milfoil (*Myriophyllum* ssp.) and waterweed (*Egeria densa*) were observed behind the monitoring units as shown in Table VII below.

It is significant that we have not found any establishment of *Arundo donax* within any of the monitoring units. *Arundo* or the Giant Reed is an invasive species that is found along the rivers and waterways of the Delta which is classified by the California Exotic Pest Plant Council (Cal EPPC) as A-1.

**Table VII. Analysis of Vegetation Change Between Spring 2002 and Fall 2005 Monitoring for Webb Tract III.**

| SITE                            | TOTAL PERCENT PLANT COVER |           | TULE ( <i>SCIRPUS</i> ) PERCENT COVER |           | SUISUN MARSH ASTER, INDIVIDUAL PLANTS |           | MASON'S LILAEOPSIS PERCENT COVER |           | WATER HYACINTH PERCENT COVER |           |
|---------------------------------|---------------------------|-----------|---------------------------------------|-----------|---------------------------------------|-----------|----------------------------------|-----------|------------------------------|-----------|
|                                 | Spring 2002               | Fall 2005 | Spring 2002                           | Fall 2005 | Spring 2002*                          | Fall 2005 | Spring 2002                      | Fall 2005 | Spring 2002                  | Fall 2005 |
| <b>W III-1</b>                  | 50                        | 97        | 30                                    | 95        | 0                                     | 00        | 0                                | 0         | 0                            | 2         |
| <b>W III-2</b>                  | 20                        | 32        | 10                                    | 20        | 0                                     | 12        | 0                                | 2         | 0                            | 0         |
| <b>W III-3</b>                  | 42                        | 35        | 15                                    | 35        | 0                                     | 15        | 0                                | 3         | 0                            | 0         |
| <b>W III-4</b>                  | 20                        | 23        | 20                                    | 20        | 0                                     | 10        | 0                                | 2.5       | 0                            | 0         |
| <b>W III-5</b>                  | NA                        | 25        | NA                                    | 15        | 0                                     | 60        | 0                                | 10        | 0                            | 0         |
| <b>W III-6</b>                  | 11                        | 60        | 3                                     | 55        | 0                                     | 00        | 0                                | 15        | 0                            | 0         |
| <b>Island Ave./ Monit. Unit</b> | 24                        | 45        | 10.5                                  | 40        | 0                                     | 1.2       | 0                                | 5.4       | 0                            | 0.3       |

Notes: \* = Plants not available for identification; P = present

The project, because of adaptive management changes, lack of duplicate control sites, and lack of duplicate installations with similar conditions does not lead to rigorous scientific experimentation and analysis. Observational data and vegetation monitoring were determined to be the most effective measures of and means for evaluating the objectives and hypotheses.

Objective 1 was successfully supported by results from the Hydrodynamic Forces Investigation. Hydrodynamic energy was dissipated (Hypothesis 1A) with varying degrees depending on the type of treatment. The results from the Hydrodynamic Forces Investigation also support the intention of the demonstration project, to experiment with effective solutions to support project objectives. Hypothesis 1B: in-channel island substrate can be conserved and/or accreted using biotechnical methods was supported as shown by the vegetation growth. Hypothesis 1C: biotechnical methods offer stable, long-term protection against erosion. The large root wads have proven to be stable and very effective under severe current and wave action regimes. Brush walls are stable but require maintenance and addition of makeup material as the brush collapses.

Objective 2 was successfully supported by results from the vegetation and wildlife monitoring, with the exception of Hypothesis 2A (habitat protected by biotechnical wave and erosion control methods will benefit priority fish species) which was not tested. Observations of sports fishing in and around the structures indicates that fish are potentially present. Terrestrial flora and fauna occurrence generally remained the same or increased supporting Hypothesis 2B: biotechnical methods will protect and possibly benefit terrestrial

biota. Vegetation established along island edges has increased supporting Hypothesis 2C: vegetation establishment along island edges will be enhanced by biotechnical wave and erosion control methods.

Especially important to note in support of Hypothesis 2B and 2C, is the large amount of voluntary recruitment of special status species: Suisun marsh aster (*Aster lentus*) and Mason's lilaeopsis (*Lilaeopsis masonii*). There was also seasonal increase of water hyacinth (*Eichhornia crassipes*) that becomes trapped behind the biotechnical erosion control structures, this does not refute Hypothesis 2C: non-native or invasive plant or animal species will not benefit from the biotechnical wave and erosion control methods. Water hyacinth (*Eichhornia crassipes*) populations are transient and do not interfere with the native terrestrial vegetation establishment. Increases in water hyacinth appears to be seasonal with die-backs occurring over winter. The increase of water hyacinth may be a result of the effectiveness of the treatments in reducing the forces of waves and currents; prior to treatment the hyacinth would have been washed away from the site.

It is significant that no *Arundo* has become established within the treatments which is a common invasive plant in the Delta and offers support of Hypothesis 2C. An increase in the size of pampas grass colonies at Webb Tract III was recorded. The pampas grass is associated with the established vegetation and is not associated with the biotechnical treatments. We do not interpret the increase of pampas grass to be a result of the treatments. *Iris pseudacorus* is found behind some of the treatments. These plants were noted during the baseline study and are not a result of the treatments. Long-term monitoring, if possible, will allow determination of the survival fitness of these invasive species behind the biotechnical wave and erosion control structures.

**Table VIII. Analysis of Vegetation Change Between Fall 2002 and Fall 2005 Monitoring for Webb Tract III.**

| SITE                      | TOTAL PERCENT PLANT COVER |           | TULE (SCIRPUS) PERCENT COVER |           | SUISUN MARSH ASTER, INDIVIDUAL PLANTS |           | MASON'S LILAEOPSIS PERCENT COVER |           | WATER HYACINTH PERCENT COVER |           |
|---------------------------|---------------------------|-----------|------------------------------|-----------|---------------------------------------|-----------|----------------------------------|-----------|------------------------------|-----------|
|                           | Fall 2002                 | Fall 2005 | Fall 2002                    | Fall 2005 | Fall 2002                             | Fall 2005 | Fall 2002                        | Fall 2005 | Fall 2002                    | Fall 2005 |
| W III-1                   | 85                        | 97        | 85                           | 95        | 0                                     | 0         | 0                                | 0         | 0                            | 2         |
| W III-2                   | 35                        | 32        | 10                           | 20        | 12                                    | 2         | P                                | 2         | 0                            | 0         |
| W III-3                   | 25                        | 35        | 20                           | 35        | 15                                    | 5         | 4                                | 3         | 1                            | 0         |
| W III-4                   | 31                        | 23        | 25                           | 25        | 1                                     | 0         | 3                                | 2.5       | 0                            | 0         |
| W III-5                   | 36                        | 25        | 5                            | 15        | 6                                     | 0         | 5                                | 10        | 1                            | 0         |
| W III-6                   | 20                        | 60        | 20                           | 55        | 0                                     | 0         | 0                                | 15        | 0                            | 0         |
| Island Ave. / Monit. Unit | 39                        | 45        | 27.5                         | 40        | 5.6                                   | 1.2       | 2.2                              | 5.4       | 0.3                          | 0.3       |

### **4.3 Little Tinsley Island**

Little Tinsley Island is an island in the Stockton deepwater-shipping channel that has experienced severe erosional forces along one side. The results of wildlife and vegetation monitoring are presented below.

#### **4.3.1 Wildlife Little Tinsley Island**

A comparison of the wildlife utilization of Little Tinsley Island is shown in Table IX. It is noted that Little Tinsley Island has a section that has intensive human utilization seasonally and on weekends. The Yacht Club has buildings and docks on the northwest end of the island. Their activities are restricted to the upland area and the waterside facilities. The wildlife monitoring was conducted midweek during times when human disturbance is minimal.

**Table IX. Analysis of Change in Terrestrial Biota Utilization of Little Tinsley Island Habitat .**

| <b>MONITORING<br/>SEASON LITTLE<br/>TINSLEY</b> | <b>BIRD<br/>SPECIES<br/>INCLUDING<br/>FLYOVER</b> | <b>MAMMAL</b>                                       | <b>AMPHIBIA</b>                                     | <b>BIRD SPECIES<br/>EXCLUDING<br/>FLYOVER</b>      |
|---|---|---|---|--|
| <b>1997<br/>Baseline Study</b>                  | 19  | 2   | 1   | 15   |
| <b>2002</b>                                     | 27  | 1   | 1   | 18   |
| <b>2003</b>                                     | 27  | 0   | 0   | 14   |
| <b>2004</b>                                     | 17  | 0   | 0   | 10   |
| <b>Average Change<br/>from Baseline</b>         | Increase of 3 for<br>the monitoring<br>period.    | Decrease of<br>1.66 for the<br>monitoring<br>period | Decrease of<br>0.66 for the<br>monitoring<br>period | Increase of 0.6<br>for the<br>monitoring<br>period |

Data sheets are included in Appendix C. for Little Tinsley Island. We did not observe an abundance of non-native animal species associated with the biotechnical wave and erosion control devices.

**Analysis of change in mammal utilization of island habitat.** The monitoring results show a decline in mammal observations. We do not consider this to be significant but rather due to opportunistic observations. In 1997, two muskrats were observed on Little Tinsley Island. No muskrat were observed on Little Tinsley Island in 2004.

**Analysis of change in bird utilization of island habitat.** There has not been an observable change in wildlife habitat on Little Tinsley other than the installed biotechnical structures. Our monitoring found that 22 different bird species were recorded in 2004 as utilizing the Webb Tract III and Little Tinsley Island. The pre-project monitoring in 1997 for the baseline found that 25 different bird species were utilizing the four Islands (Webb Tract II has since been eliminated from this pilot project). Table X below is a comparison of

avifauna utilization of Little Tinsley Island, excluding flyover. We emphasize that the biotechnical structures have stabilized and protected habitat that would otherwise be lost with wave erosion and we find that wildlife are utilizing the structures as shown by direct observation or the presence of scat.

There was also an increase in the diversity of species observed. Our monitoring found that 22 different bird species were recorded in 2004 as utilizing the Webb Tract III and Little Tinsley Island, 31 different bird species were recorded in 2002 and 29 different bird species were recorded in 2003. The pre-project monitoring in 1997 for the baseline found that 25 different bird species were utilizing the four candidate islands (Webb Tract II has since been eliminated from this pilot project).

**Table X. Comparison of bird utilization of Little Tinsley, excluding flyover.**

| <b>MONITORING<br/>SEASON LITTLE<br/>TINSLEY</b>   | <b>FORAGE</b> | <b>NEST</b> | <b>REACT</b> | <b>ROOST</b> | <b>SONG</b> | <b>SWIM</b> |
|---|---------------|-------------|--------------|--------------|-------------|-------------|
| <b>1997<br/>Baseline Study</b>                    | 38%           | 0           | 5%           | 38%          | 19%         | 0           |
| <b>2002</b>                                       | 27%           | 0%          | 8%           | 54%          | 11%         | 0           |
| <b>2003</b>                                       | 24%           | 0%          | 3%           | 67%          | 6%          | 0           |
| <b>2004</b>                                       | 49%           | 0%          | 6%           | 33%          | 8%          | 4           |
| <b>Average Change<br/>from Baseline<br/>Study</b> | -5            | NC          | +0.6         | +13          | -11         | +1.3        |

### **Vegetation Little Tinsley Island**

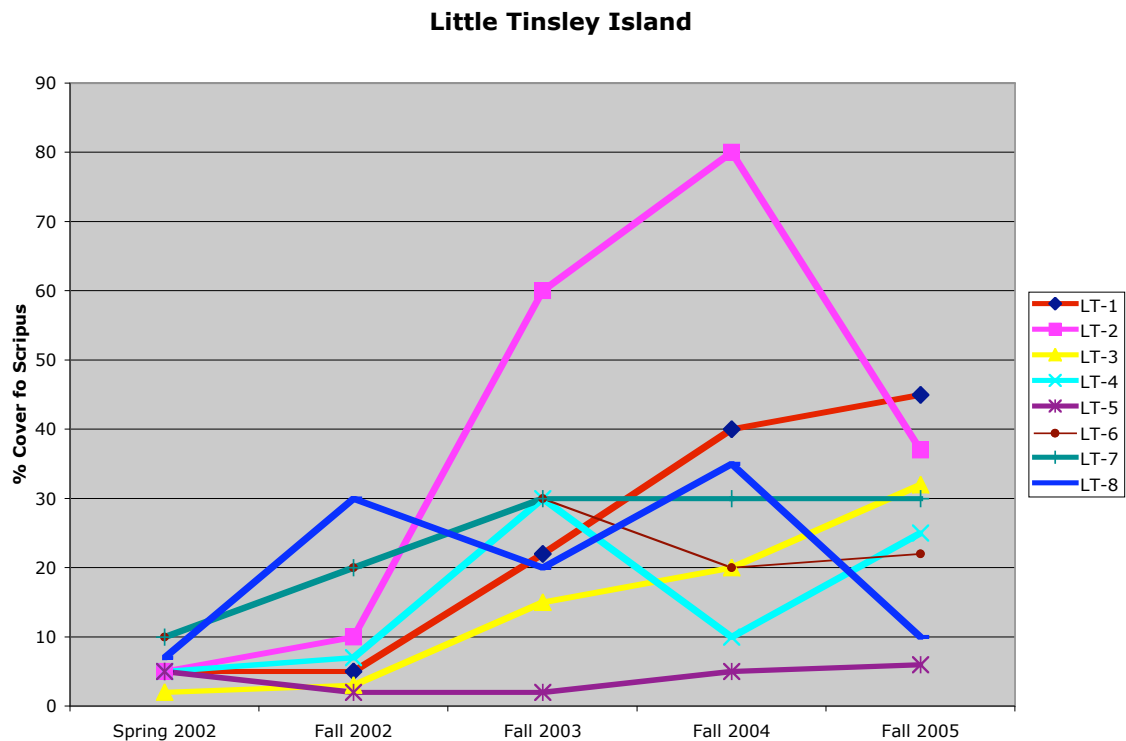
The eight monitoring units for Little Tinsley Island (Figure 4) were measured spring and fall during 2002 and 2003 and in the spring of 2004. The first monitoring event took place on February 15, 2002, (Spring) and the second took place on September 19, 2002 (Fall). The 2003 monitoring was conducted April 9, 2003, and September 24, 2003. The 2004 monitoring was conducted on April 21 and October 14, 2005 was the date of the last monitoring event.

Survey results are presented on data sheets included in the Appendix. Photographs of monitoring units are included in the Appendix. Photomonitoring locations are shown on Figure 4.

**Percent cover.** Tables XI and XII illustrate the change in percent vegetation cover from 2002 to 2005. The amount of vegetative cover increased significantly from spring of 2002 to the fall of 2005 within all monitoring units. The increase in percent cover behind the monitoring units ranged from 10 % to 75 %. Native vegetative cover consisted primarily of tule and Mason's lilaeopsis (*Lilaeopsis masonii*). None of the monitoring units showed a loss of vegetation cover Table XII.

**Scirpus Cover.** Tule coverage was estimated including both endemic common tule (*Scirpus acutus* var. *occidentalis*) and the planted California bulrush (*Scirpus californicus*) (See

Figure 7 and Tables VII and VIII). Tule or California bulrush percent coverage increased within all monitoring units. The increase of cover ranged from 1% to 40% increase in tule cover over the duration of the project as shown in Table XV.



**Figure 7.** Percent area occupied by Tules behind the monitoring units on Little Tinsley Island. The data is comparing spring 2002 monitoring to fall 2005 monitoring.

**Survivorship of Planted Stock.** During fall monitoring, vegetation appeared robust; mortality of planted stock appeared to be insignificant. It was difficult to assess success of individual plantings because of the generally uniform overall increase of tule cover. Numbers of surviving plant stock may vary from year to year dependent upon continued plantings and will not necessarily reflect total survivorship of initial plantings. The spring monitoring as shown in Table XII differs from that of the previous fall monitoring and does not reflect the annual growth pattern of the Delta.

**Special-status Species.** A highly notable voluntary recruitment of both Suisun marsh aster (*Aster lentus*) and Mason's lilaeopsis (*Lilaeopsis masonii*) occurred on Little Tinsley Island. Suisun marsh aster (*Aster lentus*) occurs on the bank bordering monitoring units. Individual plants were counted. The number of plants increased significantly from 2002 to 2004 and we assume that they are the same for 2005 but our fall survey in 2005 was beyond the flowering season when these plants are identifiable for verification.

Mason's lilaeopsis (*Lilaeopsis masonii*) occurs in sun-exposed areas within monitoring units. Percent cover was assessed. A significant increase in the presence of Mason's lilaeopsis (*Lilaeopsis masonii*) was noted from spring of 2002 to the fall of 2005 as shown in Table XI below.

**Non-native Species.** Non-native plant species occurring on the island upland of the monitoring units include purple loosestrife, pampas grass, bindweed, and annual grasses. Water hyacinth (*Eichhornia crassipes*) and *Egeria densa* were observed to have begun colonizing monitoring units. Table IX below summarizes the vegetation monitoring results comparing spring and fall of 2005. Table XI illustrates the change between Fall 2002 and the fall of 2005.

**Table XI. Analysis of Vegetation Change Spring 2002 to Fall 2005 Little Tinsley.**

| Site                           | Total Vegetation Percent Cover |           | Tule Percent Cover |           | Suisun Marsh Aster Individual Plants |           | Mason's Lilaeopsis Percent Cover |           | Water Hyacinth Percent Cover |           |
|--------------------------------|--------------------------------|-----------|--------------------|-----------|--------------------------------------|-----------|----------------------------------|-----------|------------------------------|-----------|
|                                | Spring 2002                    | Fall 2005 | Spring 2002        | Fall 2005 | Spring 2002                          | Fall 2004 | Spring 2002                      | Fall 2005 | Spring 2002                  | Fall 2005 |
| <b>LT-1</b>                    | 5                              | 60        | 5                  | 45        | 0                                    | 2         | 0                                | 0         | 0                            | 20        |
| <b>LT-2</b>                    | 7                              | 82        | 5                  | 37        | 0                                    | 6         | 0                                | 1         | 2                            | 15        |
| <b>LT-3</b>                    | 8                              | 85        | 2                  | 32        | 0                                    | 3         | 5                                | 3         | 1                            | 4         |
| <b>LT-4</b>                    | 30                             | 43        | 5                  | 25        | 0                                    | 4         | 5                                | 7         | 20                           | 6         |
| <b>LT-5</b>                    | 25                             | 31        | 5                  | 6         | 0                                    | 5         | 15                               | 20        | 5                            | 2         |
| <b>LT-6</b>                    | 14                             | 43        | 10                 | 22        | 0                                    | 0         | 3                                | 3         | 0.5                          | 5         |
| <b>LT-7</b>                    | 11                             | 48        | 10                 | 30        | 0                                    | 1         | 5                                | 5         | 0                            | 0         |
| <b>LT-8</b>                    | 7                              | 17        | 7                  | 10        | 0                                    | 0         | 0                                | 0         | 0                            | 20        |
| <b>Island Ave/ Monit. Unit</b> | 13                             | 46        | 6                  | 25        | 0                                    | 3.1       | 3                                | 5         | 3.5                          | 9         |

**TABLE XII. Analysis of vegetation change fall 2002 to fall 2005 Little Tinsley.**

| <b>Site</b>                    | <b>Total Percent Vegetation Cover</b> |           | <b>Tule Percent Cover</b> |           | <b>Suisun Marsh Aster Individual Plants</b> |           | <b>Mason's Lilaeopsis Percent Cover</b> |           | <b>Water Hyacinth Percent Cover</b> |           |
|--------------------------------|---------------------------------------|-----------|---------------------------|-----------|---|-----------|---|-----------|-------------------------------------|-----------|
|                                | Fall 2002                             | Fall 2005 | Fall 2002                 | Fall 2005 | Fall 2002                                   | Fall 2004 | Fall 2002                               | Fall 2005 | Fall 2002                           | Fall 2005 |
| <b>LT-1</b>                    | 25                                    | 60        | 5                         | 45        | 2   | 2         | 0                                       | 0         | 5                                   | 20        |
| <b>LT-2</b>                    | 16                                    | 82        | 10                        | 37        | 6   | 6         | 1                                       | 1         | 4                                   | 15        |
| <b>LT-3</b>                    | 38                                    | 85        | 3                         | 32        | 3   | 3         | 15                                      | 3         | 20                                  | 4         |
| <b>LT-4</b>                    | 20                                    | 43        | 7                         | 25        | 4   | 4         | 3                                       | 7         | 10                                  | 6         |
| <b>LT-5</b>                    | 33                                    | 31        | 2                         | 6         | 5   | 5         | 30                                      | 20        | 0                                   | 2         |
| <b>LT-6</b>                    | 45                                    | 43        | 20                        | 22        | 0   | 0         | 10                                      | 3         | 0                                   | 5         |
| <b>LT-7</b>                    | 29                                    | 48        | 20                        | 30        | 1   | 1         | 4                                       | 5         | 1                                   | 0         |
| <b>LT-8</b>                    | 45                                    | 17        | 30                        | 10        | 0   | 0         | 0                                       | 0         | 0                                   | 20        |
| <b>Island Ave / Mont. Unit</b> | 13                                    | 46        | 12.1                      | 25        | 2.6   | 3.1       | 7.9                                     | 5         | 5                                   | 9         |



## 5.0 HYDRODYNAMIC RESULTS

Boat wake energy reduction was calculated and an overall assessment of structural performance was determined for each treatment type: Brush Walls, Large Anchored Rootwads, Rootwad Wave Breaker, and Log Wave Breakers. The energy comparison does not account for all possible contributions to wave reduction; however, it provides a sense of the relative wave magnitude and effectiveness of the treatment structures. Comparative results may be found in Figure 5 and a more detailed report may be found in Appendix E.

**Brush Walls.** The boat wake energy reduction calculations for the Brush Wall structure indicated an 87% reduction in wave energy on average between the outboard and inboard staff plates. This was the highest level of wave reduction found for all of the treatment structures investigated. Direct visual inspections of boat wake attack on the Brush Wall structures indicated that much of the wake energy was absorbed by the swaying Brush Walls. Repeated observations and wake height measurements indicated that the first one to two wakes in the train were most successful at passing through the Brush Wall structure. Subsequent wakes were significantly diminished by wave interference resulting from the partial reflection of the first one to two wakes in the train. Visual inspection of the treatment under various wake attacks indicated that wake energy was best diminished when the direction of the oncoming wakes was perpendicular to the Brush Wall. The Brush Walls were least effective when attacking boat wakes broke over the top of the wall and continued toward the shoreline.

Inspection of the Brush Wall treatments indicated that significant biological decomposition had occurred and reduced the volume of wall material, especially at Webb Tract III which was installed approximately one year before the Brush Wall treatment at Little Tinsley Island. More frequent maintenance on the Brush Wall structures could help solve this issue and insure the effectiveness of the structures.

**Log Wave Breaker.** The boat wake energy reduction calculations for the Log Wave Breaker structure indicated a 68% reduction in energy on average between the outboard and inboard

staff plates. Direct observation of boat wake attack on the Log wave breaker structure indicated that wake energy was dissipated and reflected, creating wave interference and more turbulent waters on the inboard side of the structure. The large Log Wave Breaker and small Log Wave Breaker at Little Tinsley Island appeared to be in good physical condition, however the defunct “Floating Log Boom” at Webb Tract III needs to be repaired or replaced.

Anchored Large Rootwad. The boat wake energy reduction calculations for the anchored large rootwad structures indicated a 65% reduction in energy on average between the outboard and inboard staff plates. Direct observation of the boat wake attack on the anchored large rootwad structures indicated that wake energy was dissipated as the waves broke over the Large Anchored Rootwads or were interfered with by wake reflection. Due to the limited visibility of the Large Anchored Rootwads during the monitoring event, the overall physical condition and stability of the structure was not determined. Subsequent visual inspection by biological monitors through the duration of the monitoring, at low tide and high tide levels, indicated that the structures are entirely intact and stable. In addition, several Large Anchored Rootwads at Webb Tract III provided suitable habitat for the special status plant species Mason’s lilaeopsis (*Lilaeopsis masonii*) (Photo Log, Appendix A).

Rootwad Wave Breaker. The boat wake energy reduction calculations for the Rootwad Wave Breaker structure indicated a 57% reduction in energy on average between the outboard and inboard staff plates. Rootwad Wave Breaker were found to be the least effective treatment structure investigated. Direct observation of the boat wake attack on the Rootwad Wave Breaker structure indicated that wake energy was dissipated as the wake train was absorbed by the rootwads and also diminished by wake reflection and interference. The Rootwad Wave Breaker appeared to be in good physical condition.

Boat types were also documented, when possible, and linked to their corresponding wake train. Once an average wake height was determined, a comparison was made between the type of boat and height of wake created. Ski/power boats generated an average wake height of approximately 0.45 feet; yacht boats generated an average wake height of 0.81 feet. Ski/power boats were generally traveling at greater speeds than the yacht boats. Assuming that an increase in boat speed yields a larger boat wake, it is safe to conclude that yacht boats create a more significant wake. In the course of monitoring, 60 ski/power boats and only 4 yacht boats were counted. A more comprehensive study would be needed to determine which boat type and/or activity has the greatest overall impact on in-channel islands.



## 6.0 DISCUSSION

The original purposes of installing the biotechnical structures around the perimeter of the in-channel islands were to provide protection of the islands from waves/currents and to provide for the recruitment of sediment. Dr. Jeff Hart's observations are that boat waves are the primary cause of erosion and it is suggested that one way to correlate this is to compare sides of the islands which have more boat traffic with sides which have less traffic. Webb tract III, in particular shows much more "wear and tear" on the main channel side where there is more boat traffic than the side closest to the levee of Webb Tract. There has been no maintenance required on the calmer side of Webb tract. It should be noted, however, that the biotechnical wave and erosion control structures are of different design and the potential wind wave fetch is different.

Analysis. The difference in maintenance requirements may be due to boat traffic but it may also be due to the longer fetch and resulting higher wind wave action that prevails on the south side of the island. The effects of water diversions, winter flood flows and daily tides are also factors that must be considered.

It is apparent that the sediment transport in the area of the Delta where the project is located is low compared to the upper Delta channels where other projects show annual sediment recruitment (J. Hart personal communication). The Brush Walls that Hart Restoration Inc. has constructed in the north Delta have proven to be successful in recruiting sediment. The islands in the area of study are a result of the biological accretion through the accumulation of peat and deposition of organic matter under reducing conditions. It is not expected that sediment recruitment will occur in the area of the Delta where the project is located but it is anticipated that these structures will facilitate the establishment and growth of *Scirpus*, thereby providing shoreline stabilization from roots and rhizomes and potential sequestering of organic matter.

The Brush Walls have performed remarkably well, although they need a degree of

maintenance. The Brush Walls were constructed using 3" by 8-1/2' round peeler posts inserted in to the substrate. Brush (poplar or recycled Christmas trees) was inserted between the peeler posts which were on 30-inch centers. The maintenance required is due to compaction of the "brush" in the Brush Wall and the need to "top off" and tighten wires. Jeff Hart, Hart Restoration Inc., has found that Christmas trees are the most cost effective and also most effective functionally as a result of their decay resistance and structural density which is due to the trunk and limb size variation and ability to be bundled into fascicles for placement. The hydrodynamic monitoring showed that these were the most effective biotechnical structures for reducing wave energy. The effectiveness of the brush walls is a function of the variable pore size and their flexibility. Our vegetation monitoring shows that the greatest increase in vegetation cover and the occurrence of special status species is associated with the Brush Wall installations.

Table XIII summarize the biotechnical wave and erosion control treatments identifying the costs of installation and relative vegetation and wildlife habitat potential based on our observations at this time. Table XIV provides a summary of the monitoring units and the biotechnical wave and erosion treatments as they relate to the establishment of vegetation.

**Table XIII Summary of Effectiveness and Costs of Biotechnical Structures**

| <b>Biotechnical Design</b>                      | <b>Construction Material</b>   | <b>Potential For Control of Wave Action</b> | <b>Potential For Supporting Vegetation Growth*</b> | <b>Potential Support Or Habitat For:<br/>Mammals<br/>Birds<br/>Fish**</b>                                   |
|---|--|---|--|---|
| <b>Brush Walls</b>                              | Peeler core piling with Poplar or recycled Christmas trees Bound together with grape arbor wire and cinches with weights | Most effective                              | Most effective                                     | High potential with lots of surface area and voids at waterline and below<br>Mammals H<br>Birds H<br>Fish H |
| <b>Small Log Wave Breaker Little Tinsley</b>    | Peeler Core logs 6" diameter Piling and cross bracing  | Moderate                                    | Low  | Perch for avifauna<br>Mammals L<br>Birds L<br>Fish L  |
| <b>Log Wave Breaker Little Tinsley Design 1</b> | Large 12" to 18" diameter 20' long conifer logs secured to piling.   | Moderate                                    | Low  | Perch for avifauna and some aquatic habitat<br>Mammals L<br>Birds H<br>Fish M                               |
| <b>Log Wave Breaker Little Tinsley Design 2</b> | Same as above but retrofitted to fill in gaps.   | Moderate                                    | Low  | Perch for avifauna and some aquatic habitat<br>Mammals L<br>Birds H<br>Fish M                               |
| <b>Buttressed Log Wave Breaker Webb Tract I</b> | Large 12" to 18" diameter 20' long conifer logs secured to double piling with buttress support                           | Moderate                                    | Low  | Perch and some aquatic habitat<br>Mammals L<br>Birds H<br>Fish M  |

|  |   |                                      |  |   |
|--|---|--------------------------------------|--|---|
| <b>Anchored Large Rootwad</b>                          | Eucalyptus rootwads anchored with large concrete columns and cable                  | Moderate                             | Low  | Aquatic habitat with voids<br>Mammals L<br>Birds L<br>Fish H                            |
| <b>Rootwad Wall</b>                                    | Apple tree rootwads secured to peeler pole piling                                   | Moderate                             | Low. Some establishment of special-status species                            | Some perch for avifauna<br>Mammals L<br>Birds L<br>Fish M                               |
| <b>Peaked Stone Dike or Groin</b>                      | Large rocks placed as a groin below low tide line                                   | Effective current deflector          | No apparent effect   | Surface area for aquatic life with voids<br>Mammals L<br>Birds L<br>Fish M              |
| <b>Floating Log Boom</b>                               | Salt cured log secured by cable tether to piling                                    | Failed within months of installation | Not Applicable   | Not Applicable  |
| <b>Ballast Buckets</b>                                 | Weighted planting buckets   | Not applicable                       | Effective if outboard erosion control measures in place                      | Limited<br>Mammals NA<br>Birds NA<br>Fish NA  |
| <b>Floating Log Planter with Planted Mulch Pillows</b> | Conifer Logs bound together and tethered to piling to form a floating planting site | Low                                  | Low. Adaptive management has dictated a switch to ballast bucket planting    | Scat on logs indicates vertebrates have used the site<br>Mammals H<br>Birds H<br>Fish H |
| <b>Mulch Pillows</b>                                   | Mulch pillows secured to substrate behind biotechnical structures                   | Moderate                             | Highly effective in establishing vegetation provided there is no wave action | No data<br>Mammals L<br>Birds H<br>Fish NA  |
| <b>Anchored Woody Debris Pile</b>                      | Tree trimmings and Christmas trees secured by mesh to peeler pole piling.           | Incomplete at time of Monitoring     | No data  | No data   |

\* Based on 2002, 2003, 2004 and 2005 Vegetation Analysis

\*\* Subjective interpretation based on field observations:

H= High potential,  
M= Moderate potential,  
L= Low potential, and  
NA= Not Applicable

**Table XIV Summary of Types of Biotechnical Devices and Vegetation Cover**

| MONITORING UNIT                 | BIOTECHNICAL APPLICATIONS AT SITE   | PERCENT VEGETATION COVER |             | PERCENT TULE COVER |             |
|---------------------------------|---|--------------------------|-------------|--------------------|-------------|
|                                 |   | Fall 2003                | Spring 2004 | Fall 2003          | Spring 2004 |
| <b>LT-1</b>                     | Brush Wall Installed November 2001  | 48                       | 40          | 22                 | 35          |
| <b>LT-2</b>                     | Brush Wall and Rootwad Wave Breaker Installed November 2001   | 87                       | 62          | 60                 | 60          |
| <b>LT-3</b>                     | Brush Wall Installed November 2001  | 48                       | 45          | 15                 | 17          |
| <b>LT-4</b>                     | Brush Wall Installed November 2001  | 32                       | 30          | 30                 | 30          |
| <b>LT-5</b>                     | Brush Wall and Rootwad Wave Breaker Installed November 2001   | 24                       | 25          | 2                  | 5           |
| <b>LT-6</b>                     | Brush Wall, Small Log Wave Breaker, and Rootwad Wave Breaker Installed November 2001  | 47                       | 25          | 30                 | 20          |
| <b>LT-7</b>                     | Brush Wall and Log Wave Breaker #1 and 2 Installed November 2001  | 42                       | 34          | 30                 | 25          |
| <b>LT-8</b>                     | Log Wave Breaker #1 Installed November 2001   | 70                       | 85          | 20                 | 5           |
| <b>LT-8</b>                     | Log Wave Breaker #2 Retrofitted Winter 2001-02  | 70                       | 85          | 20                 | 5           |
| <b>W I Scirpus Shoal</b>        | Buttressed Log Wave Breaker #3. Installed October 2002  | 30                       | 30          | 30                 | 30          |
| <b>W I Floating Log Planter</b> | Tethered Floating Log Planter with Mulch Pillows retrofitted with Ballast Buckets. Installed October 2002 Retrofitted Fall 2003 | 0                        | 69          | 0                  | 69          |
| <b>WIII-1</b>                   | Large Anchored Rootwads Installed October 2001  | 95                       | 100         | 95                 | 93          |
| <b>WIII-2</b>                   | Brush Wall and Large Rootwads Installed October 2001  | 53                       | 27          | 20                 | 15          |

|               |  |    |    |    |    |
|---------------|--|----|----|----|----|
| <b>WIII-3</b> | Large Anchored Rootwads and Rock Groin Installed October 2001                          | 38 | 28 | 35 | 20 |
| <b>WIII-4</b> | Large Anchored Rootwads Installed October 2001   | 29 | 28 | 25 | 26 |
| <b>WIII-5</b> | Large Anchored Rootwads and Rock Groin Installed October 2001                          | 10 | 15 | 5  | 3  |
| <b>WIII-6</b> | Single and Double Brush Walls. Mulch Pillows. Floating Log Boom Installed October 2001 | 95 | 65 | 80 | 50 |

\*Adaptive management will or has resulted in replacement.

## **6.1 SUMMARY OF FINDINGS**

Relict Sacramento-San Joaquin Delta in-channel islands are scattered remnants of the once vast tidal wetlands of the Sacramento-San Joaquin River estuary. The dominant native plant at the intertidal interface between water and shore that resists wave and current action was and is the tule (*Scripus californicus* and *S. acutus*). Tule habitat provides a valuable flood and erosion control function for both tidal in-channel islands and flood control levees.

The project, as demonstration study, was undertaken to demonstrate the feasibility of “environmentally friendly” methods for controlling erosion on these Delta in-channel islands and the stabilization of these in-channel islands for protecting adjacent levees. Fourteen design structures (biotechnical wave and erosion control devices) have been tested using seven hypotheses. As a demonstration project biotechnical wave and erosion control structures were designed, built and tested at sites with different physical conditions and in different combinations on three distinctly different Delta in-channel islands

Results show a correlation between biotechnical design structure, hydrodynamic performance, and vegetation response. This report is based on previous monitoring reports, maintenance activities conducted and monitoring conducted in 2005. The project, as funded and implemented, did not allow for replicate installations for comparative evaluations because of cost limitations and the difficulty of finding similar reference sites.

Results from the four years of biological monitoring show that the project supports the objectives. The biological monitoring shows that:

The erosion of in-channel islands can be slowed, stopped, or reversed using biotechnical wave and erosion control methods as measured by increase in tule growth or cover.

Biotechnical wave and erosion control methods can be successfully installed with positive effects on special-status plant species of the Delta

### **The Project findings are:**

Hydrodynamic monitoring results indicate biotechnical treatments reduce wave height by 35%-64% and reduce wave energy by 57%-87%.

Vegetation response landward of the biotechnical wave and erosion control structures is an

efficient measure of the effectiveness of the structures;

Brush Walls have proven to be effective in reducing wave action and shoreline bank stabilization thus leading to establishment of native emergent vegetation. Plants were observed colonizing the tops of Brush Walls. In addition the Brush Walls have been shown to be effective in accumulating and trapping organic debris within and behind those structures. Routine maintenance and augmentation is required as the woody material collapses over time;

Wood structures have habitat value for birds and aquatic organisms;

Large Anchored Rootwads (large eucalyptus root masses anchored with concrete deadweights and cables) have proven to be stable and capable of effective bank stabilization under severe erosive forces. No maintenance has been required for these structures and they have been colonized by Mason's lilaeopsis;

Vegetation plantings and natural colonization of tules landward biotechnical wave and erosion control structures have resulted in an increase in the percent of vegetative cover in all units;

The increase in tule growth from 2002 to 2005, as measured by percent cover, ranged from 9 to 22 % cover on Webb Tract III and 10 to 40% cover on Little Tinsley.

The anchored root wads on the west tip of Webb III showed an increase of 9% of tule cover;

Peaked Stone Dikes on Webb Tract III are stable and effective in controlling the strong tidal currents associated with this site;

Project structures have reduced wave energy allowing for an increase in the tule cover on the submerged shoal of Webb Tract I;

The non-native invasive plant species (Water Hyacinth) washed in behind the brush walls. Water Hyacinth, a floating aquatic plant, accumulates seasonally in backwater areas where hydrodynamic forces would have previously washed it away. It is our observation that the water hyacinth does not inhibit native plant establishment. *Arundo donax* an invasive weed of the Delta has not invaded the study sites. The invasive weed Pampas Grass (*Cortaderia jubata*) has increased in size and numbers above the tide line on Webb Tract III. *Egeria densa*, a non-native plant species of the riverine aquatic bed, is developing behind the structures where there is suitable water depth;

Monitoring documented the presence of two special-status plant species in the treatment sites. An increase in the number of individuals of Suisun marsh aster (*Aster lentus*) and Mason's lilaeopsis (*Lilaeopsis masonii*) was found compared to the baseline study. Mason's lilaeopsis (*Lilaeopsis masonii*) has established on some of the Large Anchored Rootwads;

Wildlife monitoring shows no discernable trends and supports the null hypothesis. In general there was an increase in the number of bird species observed over the baseline and there was direct evidence of bird utilization of the structures for perch. There was no evidence that the biotechnical wave and erosion control structures directly supported invasive species or had an adverse effect on wildlife. The variability of wildlife utilization of the study sites is due to different seasonal and environmental factors at the times of monitoring reduces the effectiveness of wildlife monitoring as a measure of biotechnical treatments as compared to vegetation monitoring;

The Floating Log Planter at Webb Tract I was retrofitted with Planted Ballast Buckets that have proven to withstand the wave action and support tule growth. This structure is designed to sink with time and create a new tule bed. Final monitoring found that the structure had partially broken free from one of the pilings and requires maintenance;

The Log Wave Breakers on Little Tinsley Island have been modified. The modifications have been ineffective and portions of the Log Wave Breakers have been lost. The results of the experience at Little Tinsley Island were the basis for a different Log Wave Breaker design on Webb Tract I. The Webb Tract I Log Wave Breaker is designed with additional piling and buttress supports that have proven to be stable under severe wave conditions (2006 site review showed that some of the bolts had broken free and require maintenance);

Tule plug plantings behind the biotechnical structures in the organic peat soils of the Western Delta washed out and adaptive management resulted in the development of Mulch Pillows for the establishment of plantings. Mulch Pillows (fiber mats pinned to the substrate) represent a modified planting scheme using fiber mat planting pads secured to the peat soils. These were found to be necessary for retention of *Scirpus* plantings on Webb Tract III these function where there are effective wave and erosion control structures present;

Using sediment pins to monitor sedimentation/elevations was not possible with the installation of the Mulch Pillows;

The Small Log Wave Breakers (peeler poles) have been shown to be incapable of diminishing wave action as a primary barrier. After five years the structure was disintegrating; and

Rootwad Wave Breakers (apple rootwads placed within posts) were stable for four years, required no maintenance and proved to be capable of diminishing wave action as a primary barrier. The wire for these structures has failed after four years and the structure requires maintenance.

## **6.2 Summary of Hypotheses Tested**

**Hypothesis 1A:** Hydrodynamic energy can be dissipated by installation of appropriate biotechnical devices along shores. The hypothesis is supported. Results show a reduction of wave height by 35%-64% and reduction of wave energy by 57%-87%.

**Hypothesis 1B:** In-channel island substrate can be conserved and/or accreted using biotechnical methods. No data was generated which directly support this hypothesis. Tule growth measured by increase in cover will ultimately lead to the support of this hypothesis.

**Hypothesis 1C:** Biotechnical methods offer stable, long-term protection against erosion. Anchored root wads have proven to be stable and offer potential long-term protection. Other biotechnical structures require maintenance for long-term protection.

**Hypothesis 2A:** Habitat protected by biotechnical erosion control methods will benefit priority fish species. The project was unable to get permits for fish monitoring and agencies were unable to cooperate. Anecdotal observations of fishermen showed a preference for fishing around the structures.

**Hypothesis 2B:** Biotechnical methods will protect and possibly benefit terrestrial biota. Wildlife monitoring was inconclusive but we have shown that Delta birds utilize the structures for perch. Vegetation monitoring shows that special-status plant species are supported and increased by the presence of the design structures and there is an increase in

vegetation cover.

**Hypothesis 2C:** Vegetation establishment along island edges will be enhanced by biotechnical erosion control methods. This hypothesis is supported as measured by the increase in tule cover.

**Hypothesis 2D:** Non-native invasive plant or animal species will not benefit from the biotechnical erosion control methods. The data supports this hypothesis for plant species within the intertidal shoreline and there was no evidence that invasive animal species were supported. Transient floating water hyacinth accumulated behind the structures. There was no colonization of the monitoring units by *Arundo*. *Egeria* an invasive aquatic plant of the aquatic bed throughout the Delta showed a slight increase in cover in the subtidal zone behind the structures (+8%) on Webb III and a significant decrease of cover on Little Tinsley Island (-19%).

**Table XV. Summary of Biotechnical Units and Change in Tule Growth**

|                | <b>Monitoring Unit Biotechnical Application</b>   | <b>Area Of Unit</b> | <b>Change In Tule Cover<br/>Sp. 02 To F. 05</b> |
|----------------|---|---------------------|---|
| <b>LT-1</b>    | Brush Wall Installed November 2001  | 1,824 Sq.Ft.        | 40 % increase                                   |
| <b>LT-2</b>    | Brush Wall and Rootwad Wave Breaker Installed November 2001   | 735 Sq.Ft.          | 32% increase                                    |
| <b>LT-3</b>    | Brush Wall Installed November 2001  | 667 Sq.Ft.          | 30% increase                                    |
| <b>LT-4</b>    | Brush Wall Installed November 2001  | 856 Sq.Ft.          | 20% increase                                    |
| <b>LT-5</b>    | Brush Wall and Rootwad Wave Breaker. Installed November 2001  | 632 Sq.Ft.          | 1 % increase                                    |
| <b>LT-6</b>    | Brush Wall, Small Log Wave Breaker, and Rootwad Wave Breaker Installed November 2001  | 2,463 Sq.Ft.        | 12% increase                                    |
| <b>LT-7</b>    | Brush Wall and Log Wave Breaker #1 and #2. Installed November 2001  | 1,786 Sq.Ft.        | 20% increase                                    |
| <b>LT-8</b>    | Log Wave Breaker #1 Installed November 2001.  | 8,373 Sq.Ft.        | Retrofitted See Below                           |
| <b>LT-8</b>    | Log Wave Breaker #2 Retrofitted Winter 2001-02  | 8,373 Sq.Ft.        | 3 % increase                                    |
| <b>W I</b>     | Buttressed Log Wave Breaker #3. Installed October 2002  | 4,338 Sq.Ft.        | 7% increase                                     |
| <b>W I</b>     | Tethered Floating Log Planter with Mulch Pillows retrofitted with Ballast Buckets. Installed October 2002 Retrofitted Fall 2003 | 120 Sq.Ft.          | 19% increase                                    |
| <b>W-III-1</b> | Large Anchored Rootwads Installed October 2001  | 11,712 Sq.Ft.       | 66% increase                                    |

|                |  |              |                                       |
|----------------|--|--------------|---------------------------------------|
| <b>W-III-2</b> | Brush Wall and Large Rootwads Installed October 2001   | 1,222 Sq.Ft. | 13% increase                          |
| <b>W-III-3</b> | Large Anchored Rootwads and Rock Groin. Installed October 2001                                     | 3,866 Sq.Ft. | 20% increase                          |
| <b>W-III-4</b> | Large Anchored Rootwads Installed October 2001   | 3,298 Sq.Ft. | 0% increase                           |
| <b>W-III-5</b> | Large Anchored Rootwads and Rock Groin. Installed October 2001                                     | 3,438 Sq.Ft. | 15% increase                          |
| <b>W-III-6</b> | Single and Double Brush Walls. Mulch Pillows. Floating Log Boom Retrofitted Installed October 2001 | 4,965 Sq.Ft. | 39% increase<br>See Below             |
| <b>W-III-6</b> | Anchored Woody Debris Pile (Amendment Proposal) Replacing Floating Log Boom Installed 2005-2006    | 4,965        | Completed after<br>Fall 05 Monitoring |

We conclude that the biological and hydrogeomorphic monitoring completed to date indicates that the present treatments have been constructed successfully and are functioning as designed. We are observing and anticipate continued stabilization and/or reversal of shoreline erosion. We have found an increase in native emergent vegetation (planted and volunteer), conserving and protecting productive terrestrial and aquatic habitats that support important fish, wildlife, and plant communities. We find that without this project there would be further loss of habitat and impacts to the resources of the Delta from erosive forces.

### **6.3 ADAPTIVE MANAGEMENT**

Adaptive management has been implemented to meet project objectives. The adaptive management implementation has resulted in the abandonment of ineffective Floating Log Boom structures that were anchored to pilings, the use of Mulch Pillows for *Scirpus* plantings, retrofitting of the Log Wave Breakers on Little Tinsley Island and modification of the Floating Log Planter with Ballast Buckets, and construction using a different piling arrangement for the Log Wave Breaker on Webb Tract I. We became concerned when the Floating Log Boom structure on Webb Tract III started to unravel due to the effect of high-energy wave action on the harness mechanism that connected the floating logs to the anchoring pilings. During the winter of 2002-03, many of the floating logs broke loose. Some dangled from the anchoring pilings and others broke loose completely and floated downstream. Project engineers have not been able to re-design a cost-effective rehabilitation plan for the existing design. Instead, we looked at alternative energy attenuation options that use the existing anchoring piles, emulate a natural system, and integrate knowledge learned from the other in-channel island project sites.

An amendment Request for Contract # 01-N13-ERP Phase II Demonstration Project for the Protection and Enhancement of Delta In-Channel Islands was submitted and awarded. The amendment request proposed utilizing the pilings from the abandoned Floating Log Booms to test another biotechnical design at this site. The design was intended to mimic natural fluvial processes of river systems “a log jam of flood debris” that will function as habitat and control wave erosion on the shoreline of this in-channel island. The anchored woody debris pile consists of logs with rootwads and limbs that function as underwater habitat and above water perch and habitat. The Sacramento-San Joaquin Delta has lost some of its natural functions which are part of normal seasonal flood cycles that move organic debris and deposit these in debris piles. As a managed system that has numerous functions, flood

debris is treated as a liability that has been routinely removed.

We submit that log jams of woody debris are a natural part of the system that provides the following functions and values:

- Aquatic habitat for vertebrates and invertebrates
- Terrestrial above water habitat for birds and insects
- Sites for accumulation of biomass
- Barrier for reduction of wave action to minimize erosion of shorelines behind the debris.

Adaptive management actions that have been implemented during 2002 and 2003 include the following:

- Redesign of Floating Log Planter placed at Webb Tract I.
- Remove Log Boom structures at Webb Tract III.
- Placement of “Mulch Pillow” treatments in place of ballast buckets at Webb Tract III to enhance growth of planted tules.
- Retrofitting of Log Wave Breakers on Little Tinsley Island.
- Development of Buttress Log Wave Breaker design for Webb Tract I based on Little Tinsley Island.

The following table identifies recommendations and corrective actions taken in response to issues identified during monitoring in an adaptive management approach.

**Table XVI. Summary of Adaptive Management.**

| <b>Issue Observed</b>  | <b>Suggested Corrective Action</b>  | <b>Action To Date</b>   |
|--|---|---|
| <b>Webb Tract III</b><br><b>Loss of Floating Log Booms from wave action stress</b><br><br><b>Webb Tract III No treatment for erosive forces in “gap” left by removed booms</b> | Removal of log booms<br>Amendment Funding Granted to Implement New Design | Floating log booms removed in 2002<br>Design Structure installed October 2004                                     |
| <b>Webb Tract III Vegetation plantings lost (ballast buckets and rhizome plugs) by wave action.</b>  | Replanting using “mulch pillows”(more resistant to wave action)           | Mulch pillows installed and planted.<br>In place and functioning 2002   |
| <b>Little Tinsley Island Log Wave Breakers limited in effectiveness in controlling wave action because of gaps between logs.</b>   | Retrofitting by adding additional logs that were placed in gaps.          | Additional logs secured and in place 2002   |
| <b>Little Tinsley Island Log Wave Breakers Retrofitted but wave action has caused bolts to loosen and logs breaking away. Spring 2004 two sections are missing.</b>            | Retrofitting of logs washed away.   | No action at this time. It is recommended that this structure be retrofitted or removed as a navigational hazard. |

|   |   |   |
|---|---|---|
| <b>Webb Tract III Mulch pillows secured by steel “T” posts and wire.</b>  | Remove steel posts and wire and replace with biodegradable structures   | No action at this time  |
| <b>Webb Tract III and Little Tinsley Island Occurrence of invasive non-native plant Water Hyacinth floating behind biotechnical structures. (Natural dispersal)</b> | These are not rooted and transient. They do not appear to be competing with the establishment of native vegetation. | No action necessary   |
| <b>Webb III and Little Tinsley Island Brush Walls settling and becoming unstable (Wave action)</b>  | Supplemental addition of brush and shoring up of Brush Walls  | Accomplished and effective  |
| <b>Webb Tract I Mulch pillows washed out (Wave action).</b>   | Consider ballast buckets for this structure   | Ballast Buckets have been installed and as of the spring of 2004 are functioning as designed. |

## 6.4 Future Considerations

As a result of the project studies and discussions the following considerations are submitted:

Consider monitoring for a term longer than three years.

Consider coordinating with the ongoing University of Southern California study of boat wakes in the Delta. It is also recognized that there may be a need to correlate the effectiveness of biotechnical structures with changing current patterns with water diversions.

Improve collaboration of data collection efforts. Biological monitoring protocol was standardized in 2002 in an effort to more effectively determine results of the treatments. Perhaps in the future, hydrologic monitoring may be conducted in collaboration with vegetation and wildlife monitoring to compare wave action with biological effects to get a more thorough overview.

Consider vegetation monitoring for fall only on low tide series. Spring monitoring does not reflect vegetation growth that is apparent in the fall monitoring because vegetation is still recovering from winter dormancy and high flow events.

Special-status species vegetation monitoring is most accurate in the late summer / fall when the species are observable in flower or fruit.

Monitoring should be conducted by the same team of investigators for consistency.

Wildlife monitoring should be conducted more than twice a year for longer periods of time under similar environmental conditions. Strong winds have significant effects on monitoring and wildlife activity (several monitoring days were canceled and rescheduled due to high winds and waves). Birdcalls should be used for monitoring. Consider monitoring areas without the

biotechnical wave and erosion control devices such as a revetted levee as a control.

Identify and coordinate with agencies that are capable of conducting fish monitoring in and around the biotechnical wave and erosion control structures.

Consider invertebrate monitoring of the shore and colonization of the biotechnical structures and the protected substrate behind the treatments. This would be valuable for future applications particularly regarding the concern for invasive non-native species.

Consider funding for long-term maintenance of treatments. Funding for long-term maintenance and repair of the biotechnical wave and erosion control devices is recommended, as is funding for control of invasive non-native plants. (Brush Walls, the most effective treatment, seem to need minor but ongoing maintenance until vegetation is firmly established).

Consider development of different biotechnical design techniques system management alternatives for wave and erosion control.

It has been suggested that willow cuttings behind treatments may provide additional shore stability.

Develop techniques for securing Large Anchored Rootwads that will avoid cable and concert anchors. Alternatives such as weighted sandbags that will decompose should be considered.

Consider developing funding for long-term monitoring. Continued monitoring to effectively determine the long-term results and effects of treatments, beyond current project budget, is recommended.

Suggestions have been made concerning the aesthetics of the Log Wave Breakers but to date no alternatives are available.

Consider alternative methods for reducing wave action in channels to protect in-channel islands such as closing sections to boating perhaps on a rotating basis.

It is noted that the construction of the biotechnical wave and erosion control structures offer opportunities for the beneficial utilization of agricultural waste. It is suggested that future applications will be facilitated by the development of modular “bales of woody debris” for the installation of wave and erosion control structures. It is expected that a significant cost savings will result over the costs of the present pilot study if modular bales of agricultural woody waste are available (see appendix).

## **6.5 OBSERVATIONS AND LESSONS LEARNED**

The shorelines of the Delta and its in-channel islands are dynamic and exposed to extremely different physical forces dependent on location, exposure, elevation, and substrate. The placement of the designed structures, in this demonstration project, attempted to recognize the variable aspects of the physical forces impacting a section of shoreline. Our project summary observations include the following:

- 1). Delta in-channel islands are at risk from the erosive forces of wind waves, boat wakes, tidal and flood currents. Emergent and upland habitat and vegetation is being lost.
- 2). There are no historic records of the biology, ecological role or acreage of in-channel islands nor are there records of the rates of loss over time.
- 3). The dominant inter-tidal shoreline vegetation on these islands is bulrush, locally called tules (*Scirpus californicus* and *S. acutus*). Tules are considered to be “ecological engineers” for the Delta. The project did not measure for this role but inferences from observations of bank loss and associated habitat disruption in the absence of tules supports this conclusion. Natural shoreline erosion control is achieved by tules which grow at elevations in the intertidal zone and function as “Ecosystem Engineers.” The tule culm is fast growing and flexible under wave impact which functions as a wave dampener and the rhizomes are tenacious at resisting erosion. The “Old Growth Tules” persisting on in-channel islands with their extensive long-lived rhizomes (these rhizomes rival some of the oldest living organisms of California) on in-channel islands are remnants of the vast Delta ecosystem.
- 4). We found that monitoring of the fall growth of tules is an economic and efficient measure of success of the biotechnical structures and stability of in-channel islands.
- 5). Biotechnical wave and erosion control structures are functional in reducing erosion, provide habitat, and are environmentally friendly but relatively expensive to install and require maintenance.
- 6). The biotechnical wave and erosion control structures were designed to reduce wind and boat generated waves not flood events. Webb Tract III was overtopped during the winter of 05-06. The challenge for controlling the dynamic erosive forces in the Delta must recognize that the “nick point” changes hourly with the tides, seasonally with wind patterns which is a function of fetch, with each boat wake, nature of the substrate, and with location on each in-channel island.
- 7). Sediment accretion in the areas of the project, although not measured, was observed to be insignificant. The in-channel islands in this study are a result of organic accumulation and are stable as long as there is a vegetation buffer and or lack of erosive forces. Although this study was not intended to survey the stability of non-project sites, observations show that stable in-channel islands or shoals of the Delta are those with a vegetation buffer and within protected waterways. In-channel islands without a vegetation buffer and exposed to wind wave fetch and boat wakes appear to be at greatest risk.
- 8). There is a need to document the relationship and functional role of in-channel islands as part of the Delta system. There is a lack of knowledge as to the flora and fauna present and the relationship of the in-channel islands and fisheries.
- 9). The role of woody debris in aquatic systems is recognized but there is no data for the Delta.
- 10) Field observations indicate that fishermen utilize the project structures as fishing sites and there is ample evidence that avifauna utilize the structures for perch and feeding.
- 11). Metal fasteners, wire, bolts and pins used to secure wood structures require maintenance under the constant wave action in exposed situations. Fungal decay is apparent on

some of the untreated wood structures that are above the water line. Submerged or saturated woody material is subject to collapse but not decay.

- 12). In-channel islands appear to provide wave protection for adjoining levees and enhance levee stability.
- 13). We propose that the strategy for protection of in-channel islands requires: a) early detection of erosion; b) wave and current reduction along the shore; c) consideration of “soft fixes” using biodegradable materials; d) tule planting behind wave and erosion control devices; and d) an aggressive program of monitoring and maintenance of wave and current protection structures. If too much of the original “peatscape” is lost and eroding and or vertical “peat banks” are exposed protection and preservation may be problematic.
- 14). We have proposed criteria that would provide for the development of modular brush walls using recycled agricultural materials that would potentially reduce installation costs and eliminate air pollution from agricultural burning or fuel use in chipping of woody debris (see Appendix).

Biological and hydrogeomorphic monitoring indicate that brush walls, root wads, peaked stone dikes and buttressed log treatments function as designed. With these treatments we have found an increase in native emergent vegetation (planted and volunteer), conservation and protection of productive terrestrial and aquatic habitats that support important fish, wildlife, and plant communities, and protection of islands that provide important buffers to levees from erosive forces. We find that without this project there would be further loss of habitat and impacts to the resources of the Delta from erosive wave, current and tidal forces. We submit that this demonstration project is a positive model for future projects that deal with preserving and constructing new land/water interfaces specifically in the Delta, and also for other aquatic systems. We anticipate that the structures tested will serve as positive models for future Delta In-channel Island management, levee protection, and tidal wetland protection.



## 7.0 REFERENCES

### Primary References That Are The Basis For This Monitoring Report

Delta In-Channel Island Workgroup (DICIW). 2002. Monitoring Plan (updated), Phase II: Demonstration Project for the Protection and Enhancement of Delta In-Channel Islands, Monitoring Plan for Webb Tract I, Webb Tract III, and Little Tinsley Island. March 11, 2002.

Delta In-Channel Island Workgroup (DICIW). First Annual Monitoring Report, August 15, 2003. Demonstration Project for the Protection and Enhancement of Delta In-Channel Islands, Sacramento-San Joaquin Delta, California. Prepared for CALFED Project # 2001-E200.

Delta In-Channel Island Workgroup (DICIW). Second Annual Monitoring Report, January 1, 2004. Demonstration Project for the Protection and Enhancement of Delta In-Channel Islands, Sacramento-San Joaquin Delta, California. Prepared for CALFED Project # 2001-E200.

Delta In-Channel Island Workgroup (DICIW). Third Annual Monitoring Report, July 26, 2004. Demonstration Project for the Protection and Enhancement of Delta In-Channel Islands, Sacramento-San Joaquin Delta, California. Prepared for CALFED Project # 2001-E200.

Kjeldsen, C.K., et al. 1997. Baseline Analysis of Delta In-Channel Islands Proposed For Demonstration Stabilization and Restoration Projects. July 31.

### References for the Project

Allen, Hollis H. Reservoir Shoreline Erosions and Control. U. S. Army Engineer

Waterways Experiment Station Vicksburg, Mississippi 39180.

Bay-Delta Oversight Council Levee and Channel Management Technical Advisory Committee, Oct 1994. Delta Levees and Channels Department of Water Resources Reprographics.

Benda, Lee, et al, 2004. The Network Dynamics Hypothesis: How Channel Networks Structure Riverine Habitats. Bio Science May 2004 Vol. 54 No. 5. pp. 413 to 427.

Gary J. et al., 1986. Aquatic Biota Associated with Channel Stabilization Structures and Abandoned Channels in the Middle Missouri River. Environmental and water Quality Operational Studies Technical Report E-86-6, Iowa Cooperative Fishery Research Unit Iowa State University 124 Science II Ames Iowa. Prepared for COE.

California Department of Fish and Game, July 2000. Delta Flood Protection Program (A B 360) Fish and Wildlife Habitat Enhancement Guidance Document: Vol. II (Delta Plant Guide).

California Department of Fish and Game/ U.S. Fish and Wildlife Service. 1980. Sacramento/San Joaquin Delta Wildlife Habitat Protection and Restoration Plan.

California Department of Water Resources and U. S. Bureau of Reclamation. June 1990. South Delta Program Draft.

California Department of Water Resources and U. S. Bureau of Reclamation. November 1990. North Delta Program Draft.

California Department of Water Resources. 1993. Sacramento Delta San Joaquin Atlas  
California State Lands Commission, 1991. Delta-Estuary California's Inland Coast: A Public Trust Report.

California Invasive Plant Council. February 2006. California Invasive plant Inventory. Ca-IPC Publication 2006-02. California Invasive Plant Council; Berkeley, CA.

California State Lands Commission, 1993. California's Rivers: A Public Trust Report.  
Cloern, J. E., and F. H. Nichols, Eds. 1985. Temporal Dynamics of An Estuary: San Francisco Bay. Hydrobiologia.

Crain, Caitlin Mullan and Mark. Bertness. 2006. Ecosystem Engineering across Environmental Gradients: Implications for Conservation and Management. BioScience March 2006/Volume 56. No. 3 pp 211 to 218.

Dennis, N. B., D. Ellis, J.R. Arnold, and D.L. Renshaw. 1984. Riparian surrogates in the Sacramento-San Joaquin Delta and their habitat Values. In Warner and K. M. Hendrix, eds., California Riparian Systems. Univ. of Calif. Press, Berkeley.

Department of Water Resources. 1995. DWR Summary Report of USGS Delta Subsidence March 10, 1995.

Delta Protection Commission, December 1993. Background Report on Delta Environment.

England, Sidney A., and Martha Naley. 1989. Vegetation establishment and development and avian habitat use on dredged-material islands in the Sacramento-San Joaquin River Delta: Second Annual Report -- Winter and Spring 1988. U.S. Army Corps of Engineers.

England, Sidney A., and Martha Naley. 1990. Vegetation establishment and development and avian habitat use on dredged-material islands in the Sacramento-San Joaquin River Delta: Third Annual Report -- Winter and Spring 1989. U.S. Army Corps of Engineers.

England, Sidney A., and Martha Naley. 1990. Vegetation establishment and development and avian habitat use on dredged-material islands in the Sacramento-San Joaquin River Delta: Second Annual Report -- Final Report. U.S. Army Corps of Engineers.

England, Sidney A., G.S. Redpath, and Kent Nelson. 1988. Vegetation establishment and development and avian habitat use on dredged-material islands in the Sacramento-San Joaquin River Delta: First Annual Report -- Spring 1987. U.S. Army Corps of Engineers. Environmental Protection Agency, U.S. Fish and Wildlife Service, and U. S. D. A. Soil Conservation Service, Washington, D. C. Cooperative technical publication. 76 pp. plus appendices.

Federal Interagency Committee for Wetland Delineation. 1989. Federal Manual for Identifying and Delineating Jurisdictional Wetlands. U. S. Army, Corps of Engineers.

Gleick, Peter H., 2003. Global Freshwater Resources: Soft Path Solutions for the 21<sup>st</sup> Century. Science Vol. 302 28 November pp 1524 to 1528.

Grinnell, Joseph, Josephs Dixon, and Jedan M. Linsdale. 1937. Fur-bearing Mammals of California, University of California Press, two Volumes, 777 pages.

Herbold, B., and P. B. Moyle. 1989. The Ecology of the Sacramento-San Joaquin Delta: a community profile. U.S. Fish Wildlife Service. Biological Report 85 (7.22). xi + 106pp.

Hickman, James C., ed. 1993. The Jepson Manual Higher Plants of California. U.C. Berkeley Press.

Johnson, Barry L., William B. Richardson, and Teresa J. Naimo. 1995. Past, Present, and Future Concepts in Large River Ecology. BioScience Vol. 45. No. 3.

Krajick, Kevin, 2001. Defending Deadwood. Science Vol. 293, 31 August 2001. See also [www.egroups.com/group/dead\\_wood](http://www.egroups.com/group/dead_wood) and [riverwood.orst.edu](http://riverwood.orst.edu).

Mason, Herbert L. 1957. A Flora of the Marshes of California.

McCarten, N.F. 1989. Report on a study of sensitive plant species occurring in the littoral zone of Brannan Island State Recreation Area. Department of Biol., Univ. of Calif. Berkeley.

McCarten, N.F. 1990a. Report on a study of sensitive plant species occurring in the Delta State Recreation Area. Department of Integrative Biol., Univ. of Calif. Berkeley.

McCarten, N.F. 1990b Report on a study of sensitive plant species occurring in Frank's Tract State Recreation Area. Department of Integrative Biol., Univ. of Calif. Berkeley.

Moyle, Peter B. 1976. Inland Fishes of California. University of California Press.

Nakamura, Keigo, et. al. 2006. River and Wetland Restoration: Lessons from Japan. Bio Science May/ Vol. 56 No. 5 pp 419-429.

Natural Heritage Institute, October 1998. An environmentally Optimal Alternative for the Bay-Delta.

Nichols, Richard, Kent Nelson and Chris Kjeldsen, 2003. New Bioengineering Techniques Prove Successful in Restoration of the Delta In-Channel Islands. California Bay-Delta Authority Science Conference

Poff, N. Leroy, et.al., 1997. The Natural Flow Regime A paradigm for River Conservation and Restoration. Bioscience Vol.47 No. 11 pp 769-784.

RES Associates, Inc.1996. Little Tinsley Island Environmental Assessment.

Smith, J. P. (ed.). 1984. Inventory of Rare and Endangered Vascular Plants of California Special Publication No. 1 (3rd Edition). California Native Plant Society, Berkeley.

State of California Department of Fish and Game, Nongame-Heritage Program. Revised October, 1989. Endangered Plant Project.

State of California, The Resources Agency Department of Fish and Game. 1995. SB 34 Delta Levees Master Environmental Assessment.

State of California, The Resources Agency Department of Parks and Recreation, 1991. Franks Tract State Recreation Area Preliminary Engineering Volumes I-IV.

State of California, The Resources Agency, Department of Fish and Game. Revised October, 1989. List of State and Federal Endangered and Threatened Animals of California, State of California, The Resources Agency, Department of Water Resources. August, 1987. Sacramento-San Joaquin Delta Atlas,

U. S. Department of the Interior, U. S. Geological Survey. 1994. Subsidence and Carbon Fluxes in the Sacramento / San Joaquin Delta, California Fact Sheet U. S. Geological Survey Water Resources Division Sacramento, CA.

U. S. Fish and Wildlife. 1987. Vegetation Survey conducted by boat, Richard DeHaven USFWS and Frank Wernette of CDF&G.

United States Army, Corps of Engineers. 1979. Sacramento-San Joaquin Environmental Atlas.

United States Department of the Interior, Fish and Wildlife Service, April 1988. Inventory of Heavily-Shaded Riverine Aquatic Cover, Selected Islands, Sacramento-San Joaquin Delta.

Yee, David. 1990. Field Check List of the Birds of San Joaquin County.



# **Appendix A**

## **Photomonitoring 2002 to 2005**

**Appendix B**  
**Vegetation Survey Data Sheets 2002-2005**

**Appendix C**  
**Design Schematics and Photograph**  
**of**  
**Biotechnical Wave and Erosion Control**

# **Appendix D**

## **Proposal for Modular Constructed Woody Biotechnical Structures**

**Call for Collaboration/Assistance in Research and Development of  
Organic Biotechnical Erosion Control Materials for Aquatic  
Applications – Substitutes for Brush Boxes and Root Wads**